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Proceedings



of the
3rd Annual Technical Conference
of the Department of Municipal
and Community Affairs
Municipal Planning Engineers

*"Specializing in the
Municipal Environment"*

Yellowknife, Northwest Territories
December 4,5,6, 1990

Earth Sciences Library



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Municipal & Community Affairs

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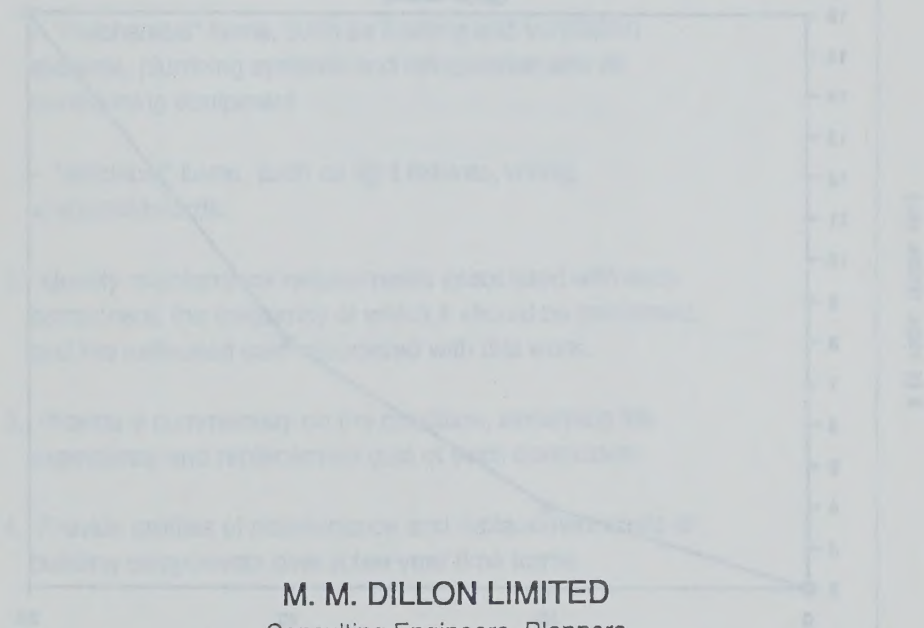
The Department of Municipal and Community Affairs would like to express its appreciation and thanks to the authors who submitted their papers for inclusion in the Proceedings.

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Aging Building Audits



M. M. DILLON LIMITED

Consulting Engineers, Planners

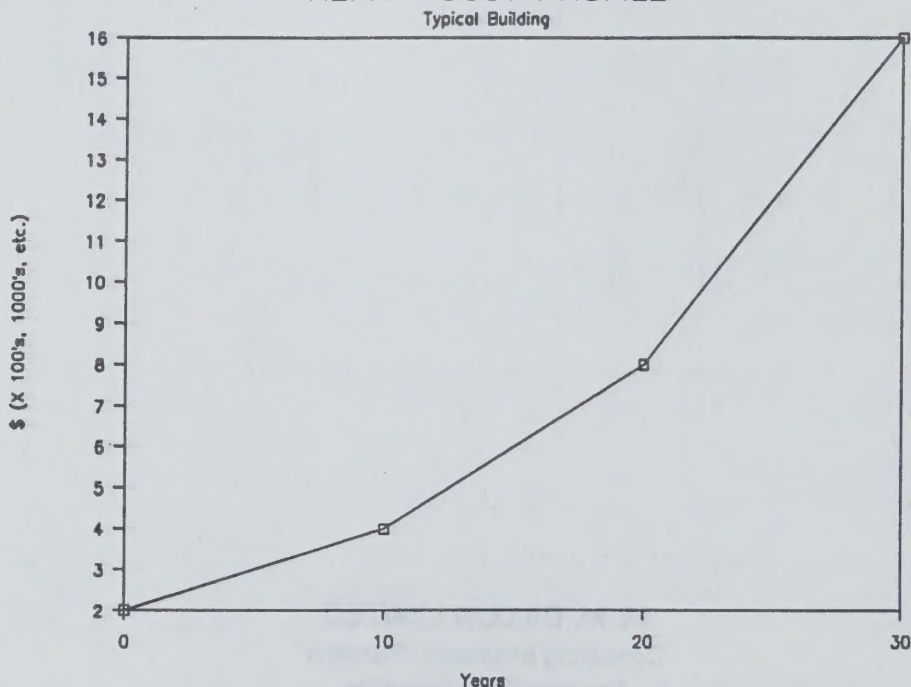
Environmental Scientists

"AGING BUILDING AUDITS"

Cities, towns, municipal governments as well as many private sector agencies often own and maintain a very significant inventory of buildings and facilities. Replacement costs of these structures are frequently in the millions of dollars.

Recent studies by the Ontario Ministry of Tourism and Recreation have indicated that maintenance and repair costs for typical recreational facilities double after the first ten years of building life, and then double again about ten years later. This exponential rise of repair costs over time is applicable to almost all buildings.

REPAIR COST PROFILE



As buildings get older, increasing amounts of money must be spent to maintain functionality and safety.

Clearly, a program that assists in the planning and implementation of proper facility maintenance, coupled with planned replacement of individual building components would be beneficial.

"AGING BUILDING AUDITS" provide this planning tool.

THE RESULT:

INCREASED LIFE EXPECTANCY OF BUILDINGS.

Aging Building Audits are investigations of the age, condition and remaining life expectancy of building components. These studies:

1. Provide a detailed inventory of building components, including:
 - "civil" items, such as parking lots, pavements, roadways, and water and sewer mains
 - "architectural" items, such as windows and doors, roofing, and painting
 - "structural" items, such as building foundations, concrete floor slabs, and structural steel
 - "mechanical" items, such as heating and ventilation systems, plumbing systems and refrigeration and air conditioning equipment
 - "electrical" items, such as light fixtures, wiring, and panelboards.
2. Identify maintenance requirements associated with each component, the frequency at which it should be performed, and the estimated cost associated with this work.
3. Provide a commentary on the condition, remaining life expectancy and replacement cost of each component.
4. Provide profiles of maintenance and replacement costs of building components over a ten-year time frame.

Aging Building Audits performed by M.M. Dillon Ltd. are prepared utilizing an in-house developed computer program which provides for ease of data analysis, and simple "sensitivity analysis" of the results to changes to the input. This computer program is available to those agencies who have had Aging Building Audits prepared by M. M. Dillon Ltd.

The following sheets
contain selected examples
of some of the input data
and results of a typical
Aging Building Audit.

TABLE 1 COMPONENT INVENTORY AND CONDITION REPORT
MAINTENANCE AND REPLACEMENT COST DATA

COMPONENT	DESCRIPTION (make, model size, area, number, capacity)	Description of Maintenance Requirement	MAINTENANCE DATA				REPLACEMENT DATA			
			Frequency	Cost per Occurrence	Start Year	Normal Life Expectancy	Present Age	Theoretical Remaining Life	Revised Remaining Life	Current Replacement Cost
1. CIVIL COMPONENTS										
1.1	Parking lot curbs - north side *	265 ft				25	4	21	21	\$3,200
1.2	Parking lot curbs - south side *	385 ft				25	6	19	19	\$4,800
1.3	Asphalt paving - north parking lot *	28,500 sq ft	2	\$2,500	1989	10	3	7	7	\$25,000
1.4	Asphalt paving - south parking lot *	23,500 sq ft	4	\$2,500	1991	10	5	5	5	\$20,500
1.5	Asphalt paving - north island	1450 sq ft				15	3	12	12	\$700
1.6	Concrete bumpers - north parking *	2 units				20	3	17	2	\$100
1.7	Concrete bumpers - north parking *	2 units				20	3	17	5	\$100
1.8	Concrete bumpers - north parking *	21 units				20	3	17	17	\$700
1.9	Concrete bumpers - south parking *	1 unit				20	5	15	2	\$80
1.10	Concrete bumpers - south parking *	1 unit				20	5	15	5	\$80
1.11	Parking lot curbs - north side *	13 units				20	5	15	15	\$500
1.12	Parking lot curbs - north side * & pedestrian walkway	2185 ft				5	3	2	0	\$300
1.13	Parking lot curbs - north side *	900 ft				5	5	0	0	\$100
1.14	Topsoil and sod - north side *	2950 sq ft	1	\$100	1988	50	20	30	30	\$2,000
1.15	Topsoil and sod - south side *	3800 sq ft	1	\$100	1988	50	20	30	30	\$2,500
1.16	Planters - north side *	2 @ 5 ft X 5 ft	5	\$50	1989	15	5	10	10	\$700
1.17	Planters - south side *	1 @ 4 ft X 4 ft	5	\$50	1989	15	5	10	10	\$600

* beside component name indicates cross reference. Refer to Table 5.

TABLE 2 MAINTENANCE COST PROFILE

1. CIVIL COMPONENTS

AGING BUILDING AUDIT

TABLE 3 REPLACEMENT COST PROFILE

COMPONENT	REPLACEMENT COST PROFILE										Annual Inflation	3.00%
	YEAR											
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998		
1. CIVIL COMPONENTS												
1.1 Parking lot curbs - north side	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
1.2 Parking lot curbs - south side	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
1.3 Asphalt paving - north parking lot	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$30,747	\$0	\$0	\$0	
1.4 Asphalt paving - south parking lot	\$0	\$0	\$0	\$0	\$0	\$23,785	\$0	\$0	\$0	\$0	\$0	
1.5 Asphalt paving - north Island	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
1.6 Concrete bumpers - north parking lot - 8%	\$0	\$0	\$106	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
1.7 Concrete bumpers - north parking lot - 8%	\$0	\$0	\$0	\$0	\$0	\$116	\$0	\$0	\$0	\$0	\$0	
1.8 Concrete bumpers - north parking lot - 84%	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
1.9 Concrete bumpers - south parking lot - 7%	\$0	\$0	\$85	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
1.10 Concrete bumpers - south parking lot - 7%	\$0	\$0	\$0	\$0	\$0	\$93	\$0	\$0	\$0	\$0	\$0	
1.11 Concrete bumpers - south parking lot - 86%	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	

AGING BUILDING AUDIT

TABLE 4 MAINTENANCE AND REPLACEMENT COST PROFILE SUMMARY

COMPONENT CATEGORY	YEAR										Annual Inflation	3.00%
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998		
<u>Maintenance Cost Profile</u>												
Civil	\$4,800	\$206	\$5,517	\$2,404	\$3,039	\$2,666	\$8,209	\$248	\$5,954	\$261		
Architectural	\$57,000	\$9,888	\$11,670	\$11,255	\$16,489	\$27,823	\$18,030	\$11,684	\$7,981	\$71,958		
Structural	\$10,000	\$1,030	\$7,957	\$0	\$20,259	\$0	\$8,358	\$5,534	\$7,601	\$31,967		
Mechanical	\$5,733	\$3,948	\$6,931	\$8,450	\$4,652	\$9,197	\$8,518	\$5,698	\$9,416	\$7,350		
Electrical	\$6,000	\$7,674	\$6,631	\$8,687	\$6,753	\$9,506	\$7,164	\$9,777	\$7,917	\$10,373		
Total Maintenance Costs	\$83,533	\$22,746	\$38,705	\$30,797	\$51,192	\$49,192	\$48,280	\$32,940	\$38,869	\$121,909		
<u>Replacement Cost Profile</u>												
Civil	\$400	\$0	\$191	\$0	\$0	\$24,437	\$0	\$30,747	\$0	\$0		
Architectural	\$0	\$84,169	\$5,305	\$13,003	\$0	\$43,473	\$0	\$0	\$0	\$2,838		
Structural	\$0	\$0	\$81,477	\$83,921	\$75,634	\$37,329	\$0	\$0	\$0	\$0		
Mechanical	\$600	\$2,369	\$7,585	\$6,119	\$20,991	\$30,373	\$50,568	\$0	\$1,267	\$18,789		
Electrical	\$250	\$361	\$1,114	\$382	\$1,182	\$13,158	\$1,254	\$430	\$1,330	\$457		
Total Replacement Costs	\$1,250	\$68,899	\$95,672	\$103,427	\$97,807	\$148,770	\$51,822	\$31,177	\$2,597	\$22,181		
<u>Total Cost Profile</u>												
Civil	\$5,200	\$206	\$5,708	\$2,404	\$3,039	\$27,104	\$6,209	\$30,993	\$5,954	\$261		
Architectural	\$57,000	\$74,057	\$16,974	\$24,259	\$16,489	\$71,295	\$18,030	\$11,684	\$7,981	\$74,894		
Structural	\$10,000	\$1,030	\$89,434	\$83,921	\$95,893	\$37,329	\$8,358	\$5,534	\$7,601	\$31,967		
Mechanical	\$6,333	\$6,317	\$14,517	\$14,570	\$25,643	\$39,570	\$59,086	\$5,698	\$10,683	\$26,139		
Electrical	\$6,250	\$8,034	\$7,745	\$9,070	\$7,935	\$22,664	\$8,418	\$10,208	\$9,247	\$10,830		
Total Costs	\$84,783	\$89,844	\$134,377	\$134,223	\$148,999	\$197,962	\$100,101	\$64,117	\$41,466	\$144,090		

Fig 1: Maint. & Replace Cost Profile

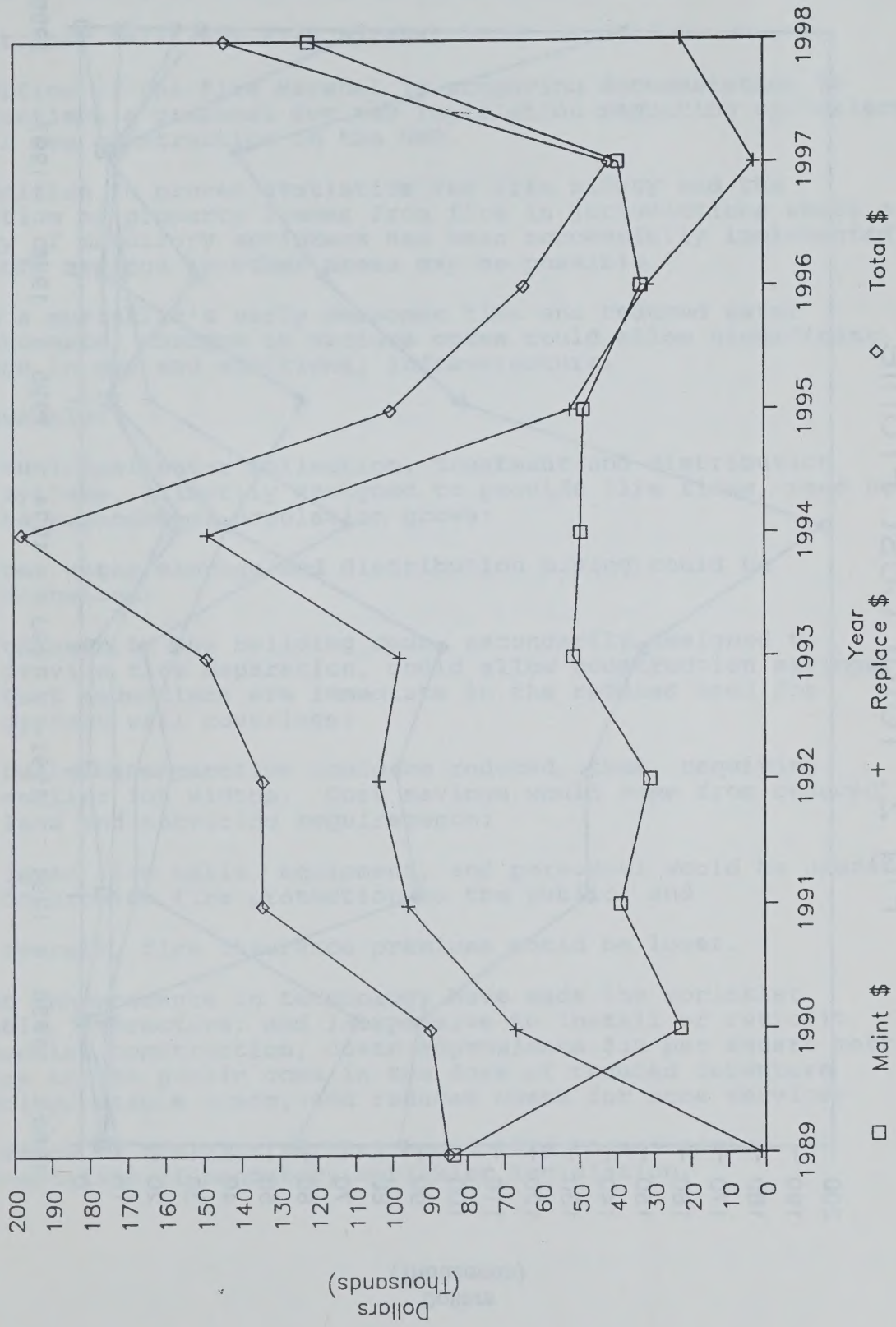
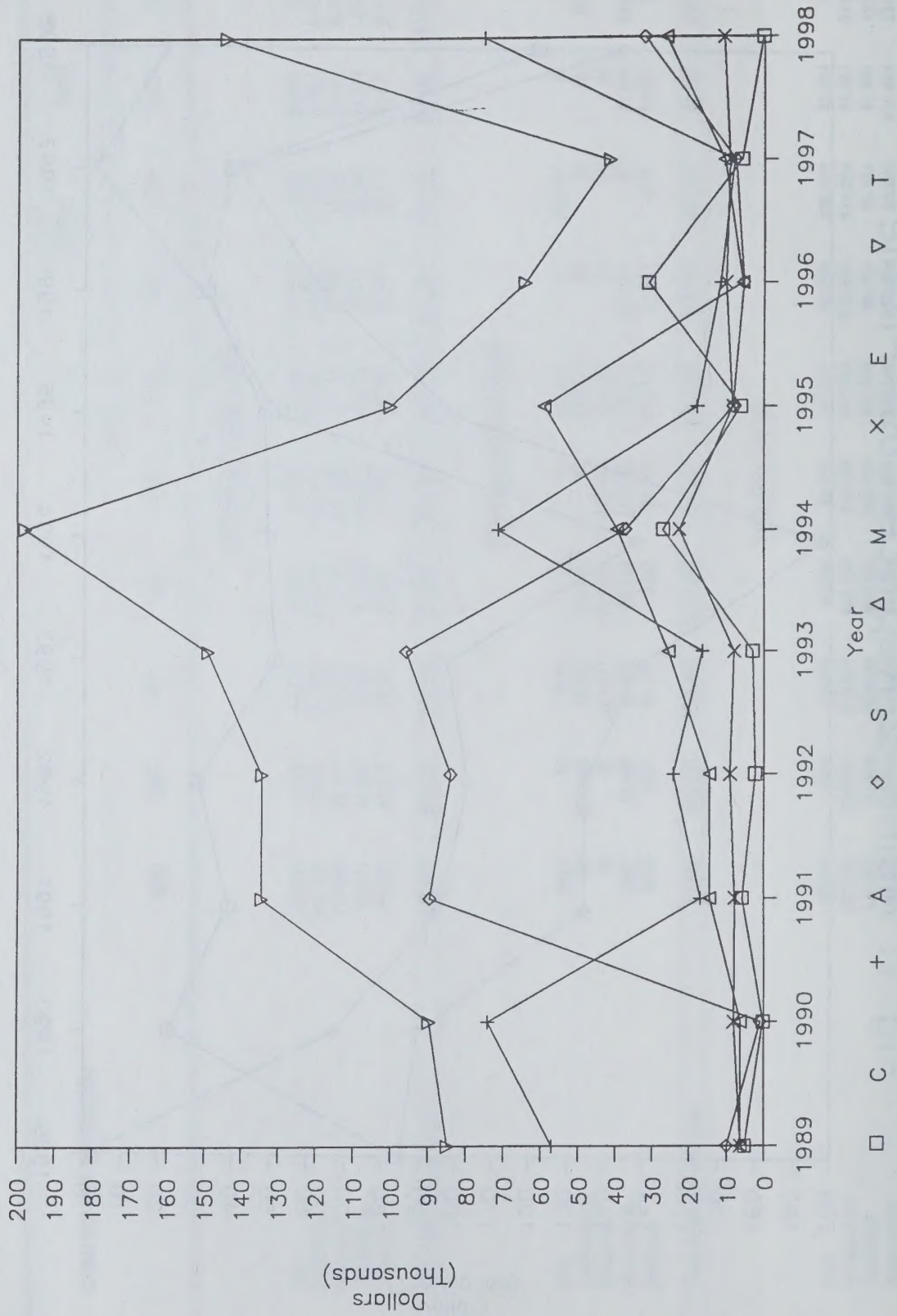


Fig 2: Total Cost Profile



Toward a Policy of Mandatory Sprinklers in the NWT

Christopher Bell, NWT Fire Marshal

The Office of the Fire Marshal is preparing documentation to substantiate a proposal for new legislation requiring sprinklers in all new construction in the NWT.

In addition to proven statistics for life safety and the reduction of property losses from fire in jurisdictions where a policy of mandatory sprinklers has been successfully implemented, spin-off savings in other areas may be possible.

Given a sprinkler's early response time and reduced water requirements, changes in various codes could allow significant savings in new and additional infrastructure.

For example:

- * municipal water collection, treatment and distribution systems, primarily designed to provide fire flows, need not be expanded as population grows;
- * new water storage and distribution piping could be downsized;
- * changes to the building code, secondarily designed to provide fire separation, could allow construction savings. Cost reductions are immediate in the reduced need for gyprock wall coverings;
- * building separation could be reduced, thus, requiring smaller lot widths. Cost savings would come from reduced land and servicing requirements;
- * fewer fire halls, equipment, and personnel would be needed to provide fire protection to the public; and
- * overall, fire insurance premiums would be lower.

Recent enhancements in technology have made the sprinkler reliable, attractive, and inexpensive to install or retrofit. In residential construction, costs approximate \$30 per square metre. Savings to the public come in the form of reduced debenture financing, stable costs, and reduced costs for some services.

The Office of the Fire Marshal would like to see early implementation of mandatory sprinkler legislation.

PIPE COLLAPSE INVESTIGATION AND REMEDIATION IN DAWSON CITY, YUKON TERRITORY

B. C. Grieco¹ and K. R. Johnson²

ABSTRACT

Dawson City, Yukon Territory is a community of approximately 1,500 people, located in the mid-western section of the Territory, in an area of discontinuous permafrost. Since the City's buried water and sewer system was placed into operation in 1980, the high density polyethylene pipe has required a remedial works program in the fall of each year to repair ovalled and flattened sections of the sewer main.

UMA Engineering undertook a study in 1986, on behalf of the Yukon Government, to review previous design information, construction procedures, and repair reports in an effort to remediate this problem. Based on this study, design alternatives were developed to improve performance of the new extensions to the buried utilities in the City.

The study recommended a trench/pipe design configuration which could reduce the incidence of pipe collapse by trench insulation, perforated drain tubing, and tensile reinforcing mesh. Other recommendations were also made with regard to the related problems of localized failures near service connections, and pipe failures near hydrants.

¹ Senior Design Specialist, Arctic Engineering Division, UMA Engineering Ltd., Edmonton, Alberta.

² Project Engineer, Arctic Engineering Division, UMA Engineering Ltd., Edmonton, Alberta.

1.0 INTRODUCTION

Dawson City, Yukon Territory is a community of approximately 1,500 people, located in the mid-western section of the Territory, in an area of discontinuous permafrost (see Figure A). The city's water and sewer services are provided by a buried utility system which was completed in 1980. Since placed into operation, the existing insulated polyethylene system (see Figure B) has required a remedial works program in the fall of each year to repair ovalled, and flattened sections of the sewer main. This has been particularly prevalent at service connection locations. Problems have also been experienced with leaning hydrants, and pipe breakages at the connection to the hydrant base.

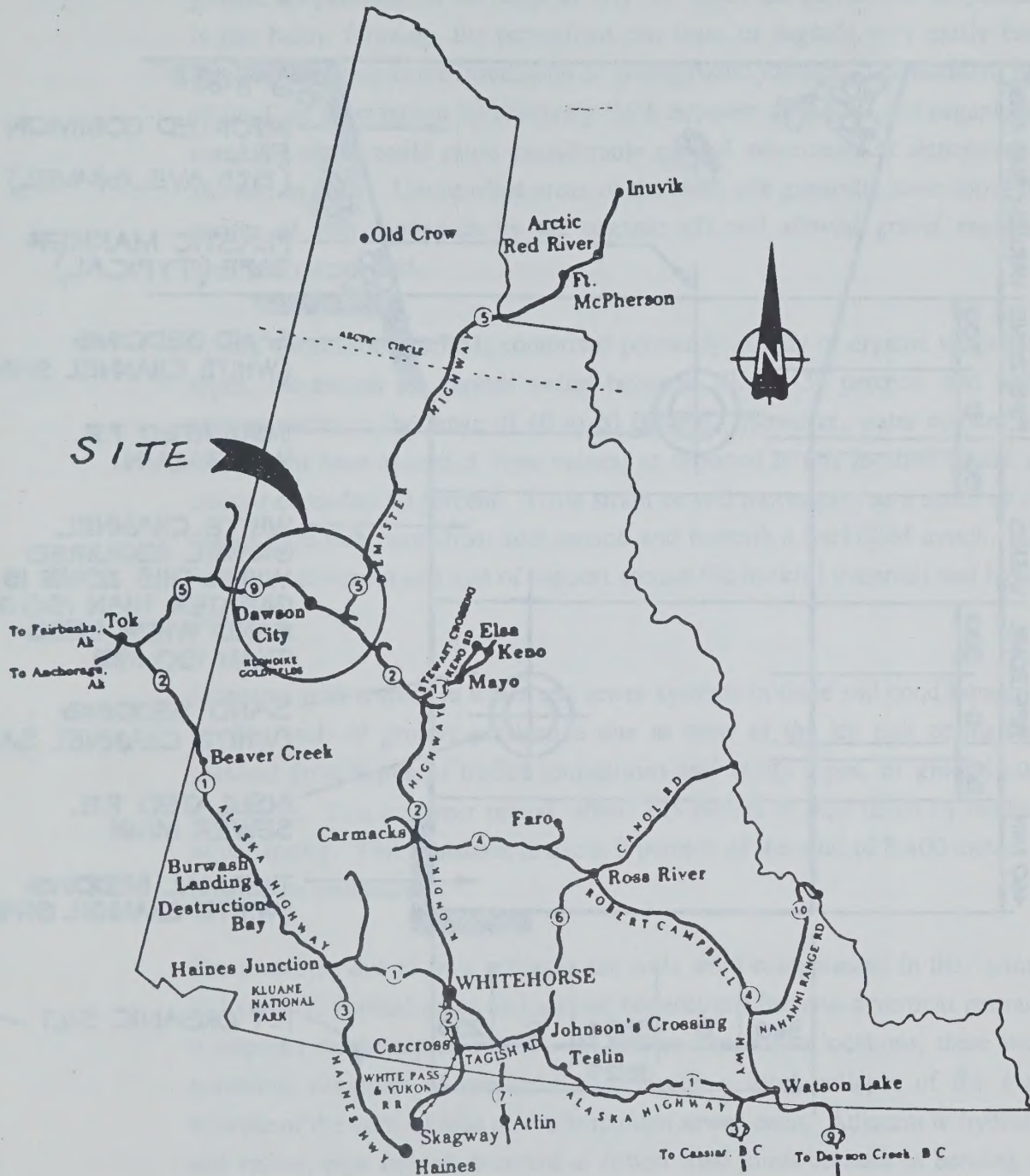
UMA Engineering undertook a technical study, on behalf of the Yukon Government, to review previous design information, construction procedures, and repair reports. Based on this review, design alternatives were developed to improve performance of the new extensions to the buried utilities in the city. Design alternatives also considered future placement of bituminous surface treatment (BST) on the roadways.

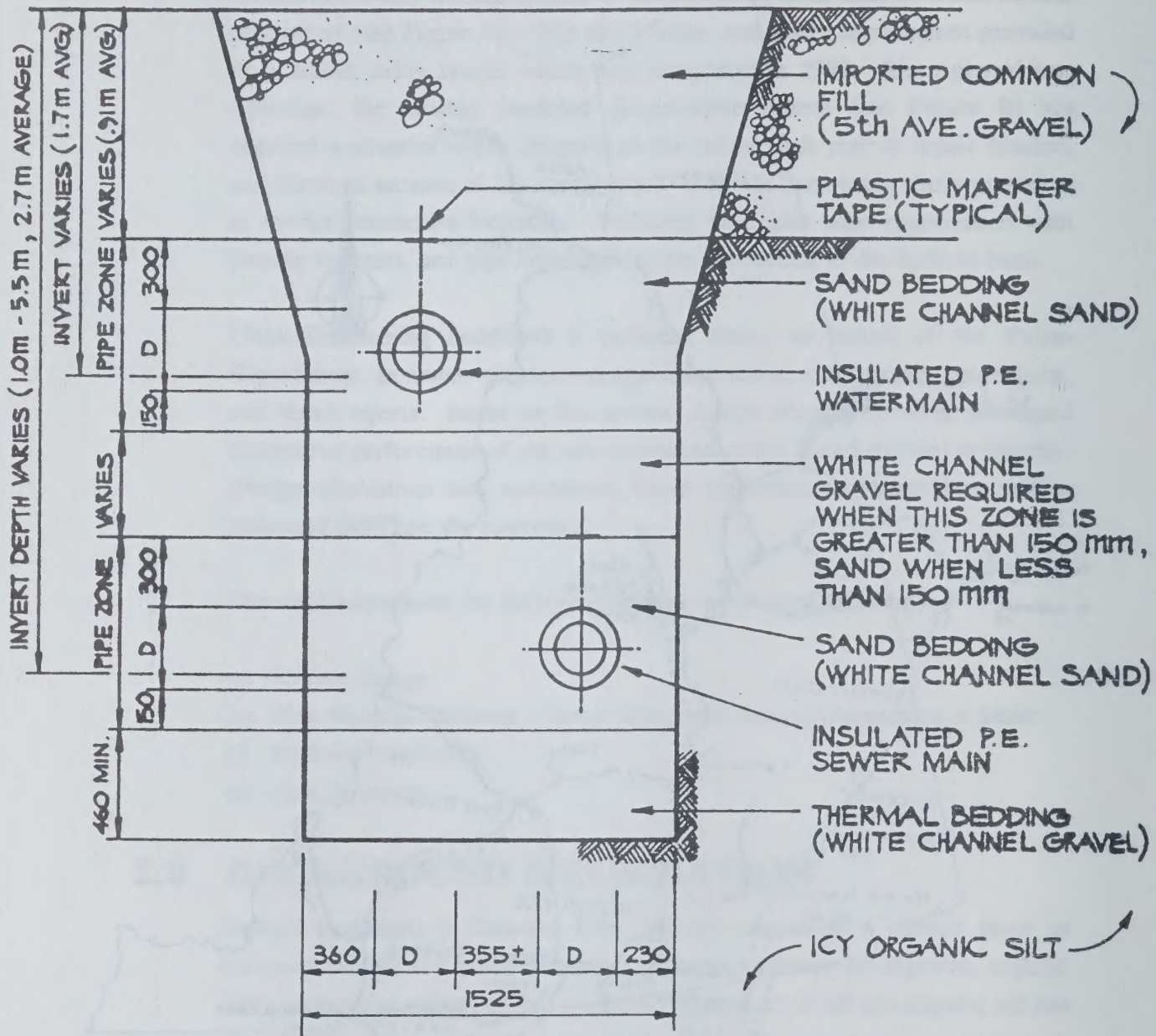
The study considered the following aspects of the detailed design:

- a) Trench Design
- b) Pipe Material Selection - Sewer Main and Service Connection at Main
- c) Hydrant Installation
- d) Cost Estimates

2.0 BACKGROUND INFORMATION

Subsoil conditions in Dawson City typically consist of a surface layer of common road fill 0.6 to 0.9 metres in thickness, underlain by organics, organic silts, and silts to a depth of 3 to 5 metres. This layer of silt and organic silt has an ice content varying from zero to greater than 50 percent excess ice content. Beneath this layer of organic silt, a layer of alluvial gravels has been deposited by the Yukon River. These gravels are relatively dense and thaw stable.





SCALE 1:25

DAWSON CITY WATER AND SEWER TECHNICAL REVIEW REPORT

EXISTING TRENCH CROSS-SECTION

uma

FIGURE B

This area is in the widespread discontinuous permafrost zone, with mean ground temperatures in the range of -1.5°C . Since the permafrost temperature is just below freezing, the permafrost can thaw or degrade very easily from disturbances such as the installation of underground utilities. The northern part of the City is underlain by relatively-thick deposits of the silt and organic silt material, which could cause considerable ground movements or settlements if allowed to thaw. Undisturbed areas of the town site generally have about 0.6 metres of peat, underlain by the organic silt and alluvial gravel sequence previously described.

Where the subsoil profile is comprised primarily of silty or organic silt subsoil types, the excess ice content varies between 20 and 30 percent, and water content varies in the range of 40 to 60 percent. However, water content and ice content have exceeded these values, as reported in one location where ice content exceeded 50 percent. Thaw strain or soil movement, as a result of the thaw of ice rich permafrost silts around and beneath a backfilled trench, may result in settlement and loss of support around the backfill materials and buried piping.

Problems with respect to water and sewer systems in these soil conditions may be the result of ground subsidence due to thaw of the ice rich permafrost, seasonal frost heave of buried foundations and utility pipes, or groundwater conditions. In a two year period, about 225 metres of pipe failed by ovaling or collapsing. This translates to about 3 percent of the total of 8,400 metres of pipe in the community.

The problems due to frost action in the soils were compounded in the vicinity of hydrants, vertical risers and service connections because a vertical restraint is imposed on the piping system. At service connection locations, there were numerous examples of service risers causing a local collapse of the main because of the vertical load on the horizontal sewer main. Adjacent to hydrants and valves, pipe failures occurred at fusion weld joints because of bending or torque along the connecting pipe.

3.0 INVESTIGATION

Information review included a variety of engineering reports on predesign, geotechnical, construction inspection and annual remedial works. A review was also made of construction contract drawings and specifications, hydrant re—alignment field notes, utilities record drawings, and ball pig test data.

Meetings were held with personnel from the Yukon Government and Stanley Associates Engineering Ltd. to discuss the design, construction inspections, post construction review, and remedial works associated with the project.

A detailed geotechnical review was also carried out by Hardy Associates (1978) Ltd. as part of the overall technical review. The review included trench and backfill stability, and the associated design considerations, an evaluation on the existing buried piping system, and two geothermal analyses of various design alternatives.

4.0 DISCUSSION

The geotechnical review attributed the primary source of distress in the buried polyethylene pipe to:

- a) a loss of vertical support due to thawing of ice rich permafrost beneath the select fill material, and
- b) loss of lateral support due to thawing of ice rich permafrost in a horizontal direction.

4.1 Pipe Material

A number of pipe materials were considered for the future extensions to the utility system. Those materials included high density polyethylene, ductile iron, steel, polyvinyl chloride, fibreglass reinforced plastic, reinforced concrete, asbestos cement, and aluminum.

High density polyethylene (HDPE) pipe, with butt fused joints, is considered to be one of the most suitable piping materials for permafrost applications. This is attributed to its qualities of lightness, flexibility, leakage tightness, pull-out resistance, corrosion resistance, insulation system compatibility, and reasonable installation cost. Another particular advantage is its internal freeze damage resistance.

There are two notable disadvantages of this material. The first disadvantage is its low collapse resistance, therefore the pipe relies upon bedding material to produce the support needed to resist collapse. The second disadvantage is the difficulty in completing a field joint repair, which is thrust resistant, without the use of butt fusion equipment.

Ductile iron pipe and steel pipe, on the other hand, have high tensile strength and collapse resistance, but they have lower corrosion resistance, and lower resistance to internal freeze damage.

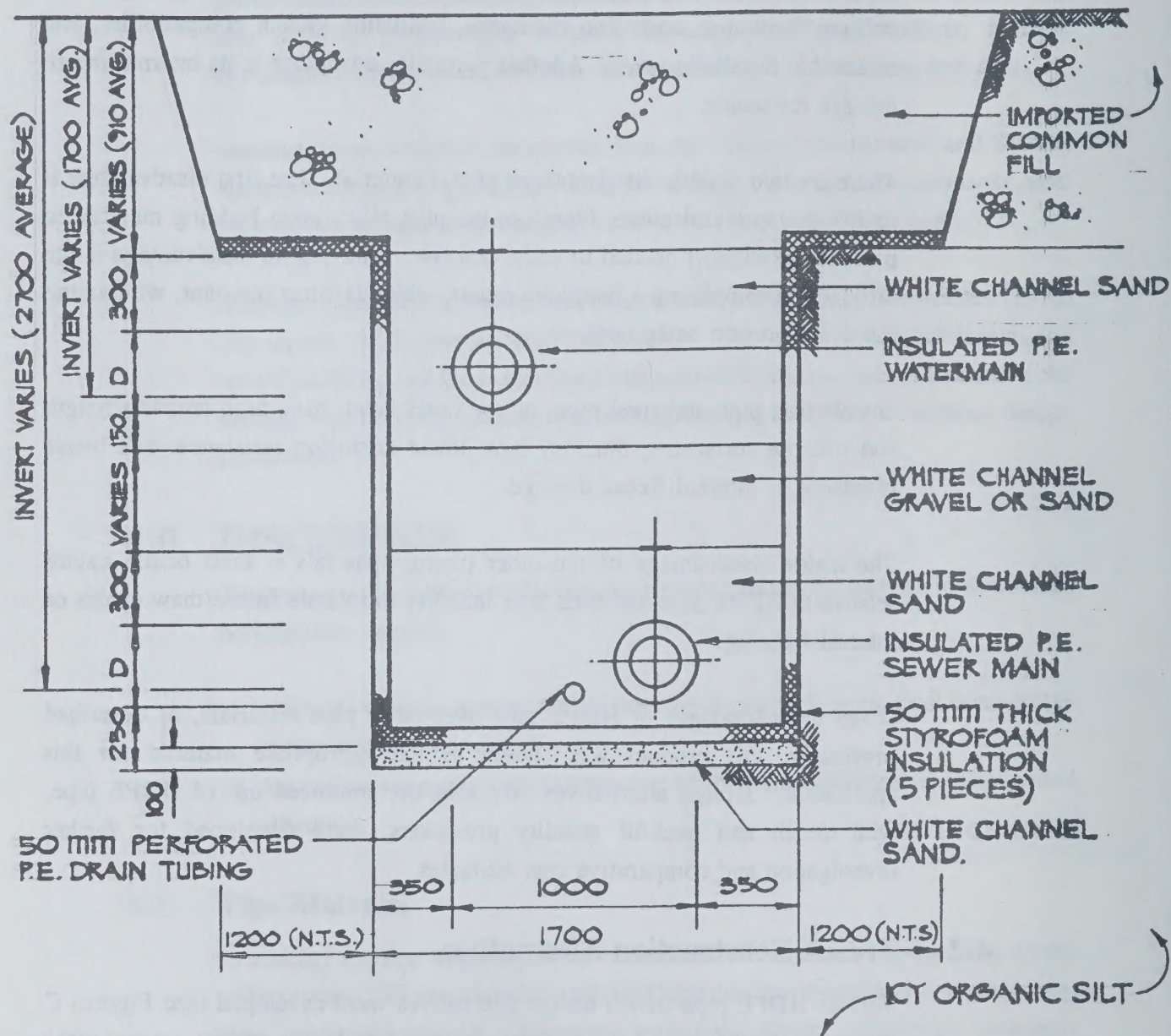
The major disadvantage of the other piping materials is their brittle nature relative to HDPE pipe and thus their inability to tolerate freeze/thaw cycles or internal freezing.

Given the advantages of HDPE pipe over other pipe materials, as described previously, this product was chosen as the appropriate material for this application. Design alternatives involving the continued use of HDPE pipe, with trench and backfill stability provisions, were developed for further investigation and comparative cost estimates.

4.2 Trench Construction Alternatives

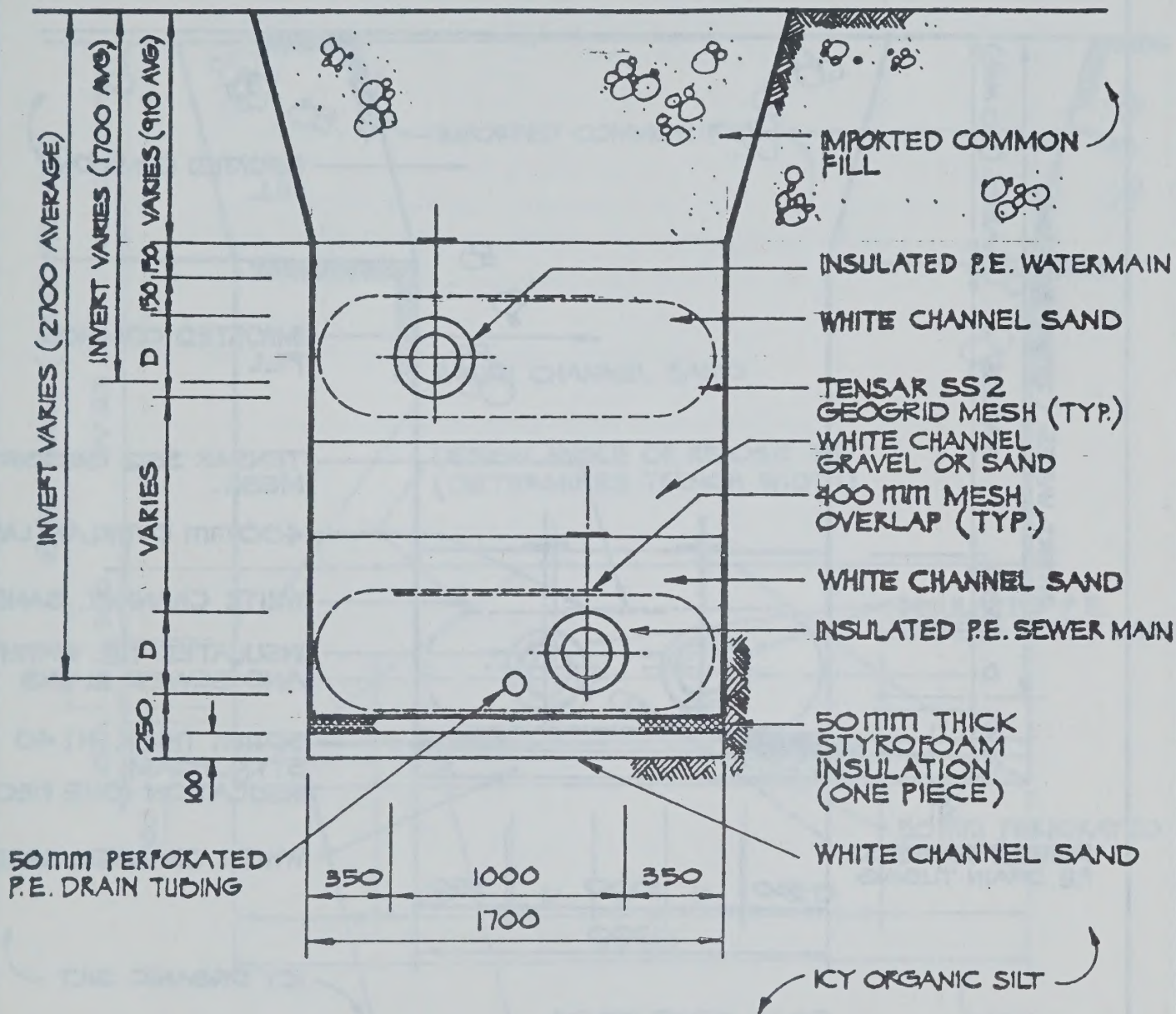
Various HDPE pipe/trench design alternatives were developed (see Figures C through G) based on recommendations in the geotechnical review, review other available information and observations on the existing installation.

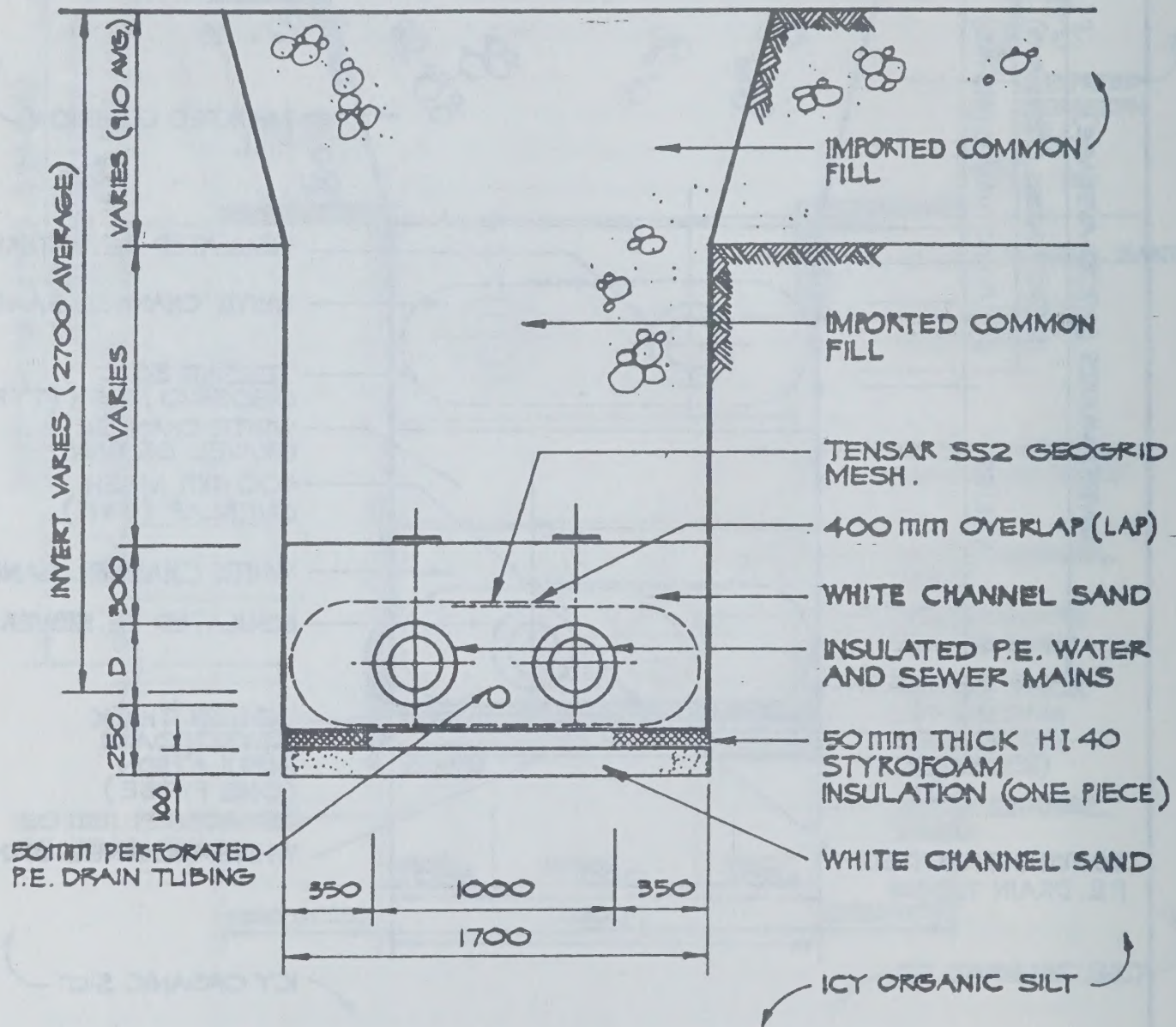
All of the alternatives utilize styrofoam board insulation in the trench to limit thaw penetration below, and in one case to the sides of the pipe (see Figure C). This will reduce the loss of vertical and lateral soil stability, and frost heaving. Two of the alternatives use tensile reinforcing mesh in the trench backfill



SCALE 1:25

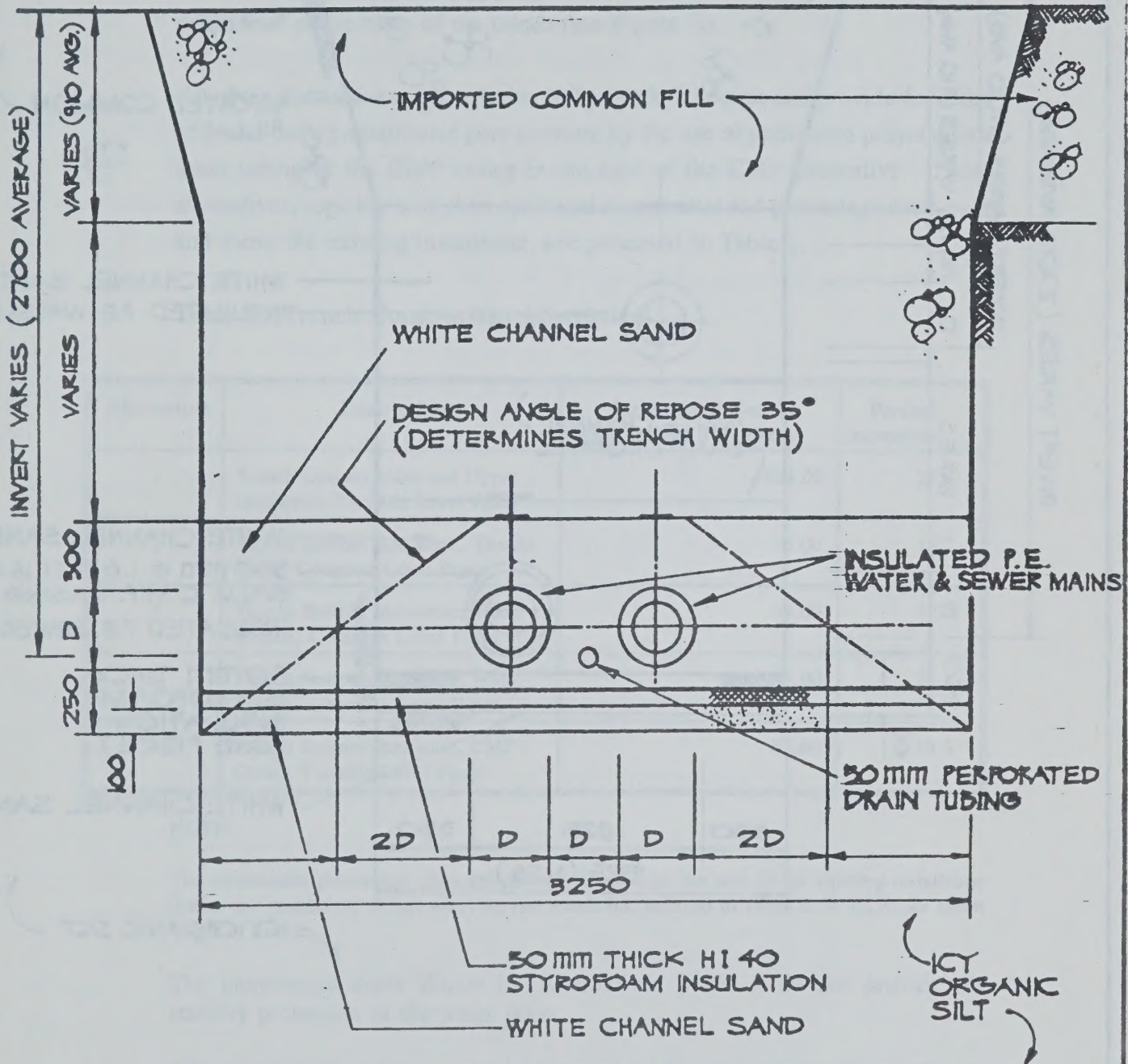
DAWSON CITY WATER AND SEWER TECHNICAL REVIEW REPORT
 ALTERNATIVE 1 - 5 PIECE INSULATED TRENCH,
 VARIABLE LEVEL PIPES



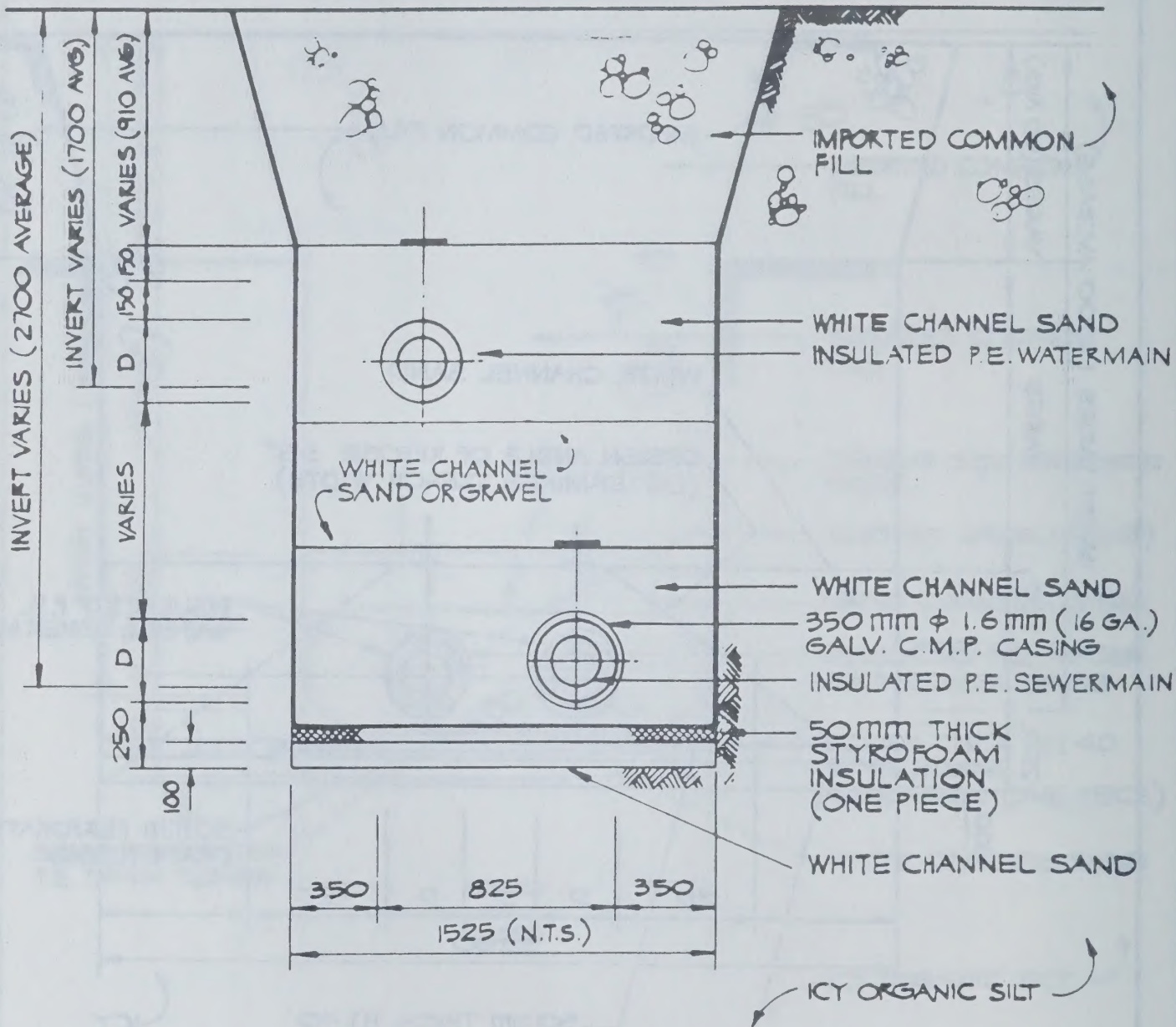


SCALE 1:25

DAWSON CITY WATER AND SEWER TECHNICAL REVIEW REPORT
 ALTERNATIVE 3 - TRENCH STABILIZATION WITH GEOFABRIC,
 PIPES AT COMMON LEVEL



SCALE 1:25



material (see Figures D and E). Another of these alternatives specifies a wider trench (see Figure F). The final alternative identifies the use of corrugated metal pipe (CMP) as a casing over the HDPE sewer pipe in order to prevent the loss of lateral pipe support due to horizontal thawing of ice rich silt permafrost at the sides of the trench (see Figure G).

All of the alternatives utilize Series 100 polyethylene pipe and provide for relief of freeze-back groundwater pore pressure by the use of perforated polyethylene drain tubing or the CMP casing in the case of the CMP alternative. These alternatives, together with their estimated incremental and percentage costs over and above the existing installation, are presented in Table 1.

Table 1: Trench Construction Alternatives

Alternative	Description	Incremental Cost in 1986 Dollars Per Metre	Percent Increment
1	Trench Bottom Sides and Upper Insulation, Variable Level Pipes	134.00	27.7
2	Trench Bottom Insulation, Tensile Mesh, Common Level Pipes	76.00	15.7
3	Trench Bottom Insulation, Wide Trench, Common Level Pipes	95.00	19.7
4	Trench Bottom Insulation, Wide Trench, Common Level Pipes	138.00	28.5
5	Trench Bottom Insulation, CMP Casing Variable Level Pipes	95.00	19.6

NOTE:

The incremental percentage costs are calculated based on the cost of the existing installation (mains and manholes, except water service manholes, indexed to 1986) at \$483.50 per metre length of trench.

The incremental costs shown for Alternatives 2 and 5 do not provide for stability protection of the water main.

All of these alternatives, except alternative 4, are considered to provide approximately the same degree of trench and backfill stability protection for the polyethylene sewer main. Alternative 4 is considered to provide a somewhat lower measure of protection.

4.3 Sewer Service Connections

If was evident by the number of incidents of localized flatter of the sewer main at sewer service connections that cutting into the top of the main for the installation of mechanical clamp-on type service saddles tends to weaken the main. This is further compounded by the vertical sewer service risers exerting a force downward on the saddle due to backfill or thaw settlement earth loads.

The repair reports also showed evidence of increased permafrost thaw into and below the thermal bedding material at service connection locations. This may be attributed to increased groundwater movement and resultant increased thawing due to groundwater leakage into the main at the disturbed sewer service connection saddles.

The information collected points to needed improvements in the service connection design. A new service connection fitting should be identified that:

- a) does not weaken the main,
- b) enters the main at a lower angle to the horizontal thus reducing vertical forces on the service saddle, and
- c) is more leak-tight.

4.4 Hydrant Installation

The existing on-line hydrants were installed in corrugated metal pipe manholes on concrete bases, which rested on a styrofoam insulation layer. A number of various problems have occurred with this design.

The most serious problem has been the failure of the polyethylene butt fusion weld at the transition flange from the 45° cast iron elbow, which is just outside the corrugated manhole wall. Occasional cracking of the cast iron elbow fitting has also occurred. In most of these cases it was evident that settlement occurred in the pipe leads to the hydrant manholes, thus causing differential movement, and stresses near the transition flange. The settlement is likely permafrost thaw related.

The associated stresses have been relieved in the past by removing the bracing between the upper part of the hydrant and manhole. However, the resultant hydrant lean, of up to 8° in some instances, required correction by excavating the lead, and adjusting the bedding.

Hydrant elevation records showed that hydrants heaved and settled as much as 100 mm with the annual freeze/thaw. To alleviate this problem, it is necessary to reduce the amount of installation permafrost thaw and annual thaw below the hydrant leads and hydrant bases. This would reduce the amount of freeze/thaw movement and the resultant stresses.

Hydrant elevation records show that frost jacking is not evident with the use of the present hydrant manhole/base design.

4.5 Bituminous Surface Treatment

The bituminous surface treatment (BST) is seen to cause a small increase in the thaw depth of the backfill. An existing test section with BST surface treatment did not provide the necessary data on surface temperature to support the assumptions made for the thermal analysis simulations. Therefore, although the effects of the BST are shown to increase thaw by a small amount, the input data was not well supported. The design alternatives are relatively insensitive to small changes in thaw around the trench, but it was suggested a further 1 - 3 summers of monitoring with an increased amount of near-surface temperature instrumentation should be carried out prior to a major program of BST application.

5.0 CONCLUSIONS

Various remedial actions have been discussed, and a total of five possible pipe/trench design options were investigated. Each of these options would be beneficial in accommodating the effects of thaw subsidence, and thereby assist in reducing vertical deflection and each has a reasonable chance of reducing the incidence of repairs associated with a future system. However, because of the uncertainties involved in widely varying subsurface ice contents, groundwater conditions during construction, and the quality control of insulation or backfill placement during construction, the possibility of future repairs is still present.

It is likely that implementation of these remedial actions will reduce the incidence of repairs to a lower and more acceptable level than was previously experienced.

6.0 RECOMMENDATIONS

It was recommended that a trench/pipe design configuration similar to that shown in Figure E (Alternative 3) be adopted. This design will alleviate potential vertical thaw settlement and loss of lateral support for the trench backfill materials, and provide for relief of groundwater pore pressure caused by freeze-back of saturated material surrounding the pipe. The design involves trench bottom board insulation, pipes at common level, Series 100 polyethylene sewer pipe, perforated drain tubing, and tensile reinforcing mesh surrounding select compacted fill material layers surrounding the pipes.

Horizontal water flow within the select material filled trench must be reduced or prevented by the use of silt/clay plugs extending the full width and depth of the select fill zone. These should have a thickness of about 2 metres along the pipe trench, and should be installed at 30 metre spacings, or as required by local topography. A sand-bentonite mixture might also be considered in order to reduce local frost effects at the ditch plug location.

Risers and connections from the buried main to service connections should exit from the trench at an angle of about 30° to the horizontal, in a separately excavated trench, in order to prevent excessive vertical stresses on the sewer main. In addition, sewer service connections should be made using polyethylene socket fusion saddles. Joints in the polyethylene sewer service should be butt-fused or socket fused, in order not to weaken the main at the connection point, and to provide for leak-tight, pull-out resistant joints.

As permafrost thaw at the sides and bottom of the backfilled trench may result in loss of bedding material support for the pipes, bedding material should be maintained as cool as possible prior to use. This may be achieved by storing it in a shaded location. The duration of time which the trench remains open during construction should also be minimized to reduce permafrost thaw.

Insulation of the trench base, as recommended for the water and sewer mains, should be carried along the hydrant leads to the end of the hydrant. This would result in reduced initial permafrost thaw settlement and reduced annual thaw settlement/frost heave in the leads and at the hydrant manhole, and thus prevent damage to the pipe at hydrant manhole transition points.

Frost jacking does not appear to be a problem with the present hydrant manhole base design. However, if the base size were to be reduced, then alternate provisions should be made to prevent frost jacking. The use of coatings at the seasonal freezing zone would reduce the adfreeze bond and thus prevent a potential problem.

An additional 1 to 3 summers of monitoring, with an increased amount of near-surface temperature instrumentation, should be carried out to provide adequate data for the BST thermal analysis simulations. This is recommended before any major program of BST application occurs.

A second instrumentation program should involve thermistors and risers fixed to the buried utility pipe at a few selected locations of any new extension. These should be designed to gather data over a 2 to 3 year period on any thaw, settlement or heave of the buried piping. This should be measured simultaneously at 3 to 6 locations of new sewer installation.

ACKNOWLEDGEMENTS

Yukon Territorial Government, Department of Community and Transportation Services.

Mr. J.A. Cormie, P.Eng. Director, Municipal Engineering Yukon Territorial Government.

Town of Dawson City, Yukon Territory

REFERENCES

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Mad Dog Cement

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3rd ANNUAL TECHNICAL CONFERENCE

of the

Department of Municipal and Community Affairs

Municipal Planning Engineers

MAD DOG CEMENT

15-50-1

1.0 INTRODUCTION

Paved streets within Yellowknife often suffer from severe distress because of the thaw - consolidation of ice-rich permafrost. The problem is compounded by a severe shortage of suitable aggregate to replace the ice-rich and/or frost susceptible subgrade soils.

At the present time the City of Yellowknife is desperately short of sand and gravel and is taking measures to conserve this scarce resource. Nevertheless, many thousands of tons of sand are used each year where alternative materials might well be used such as for trench backfill, embankment and road subbase.

Similarly the Department of Transport is frequently faced with very expensive crush and haul contracts particularly in the Highway system surrounding Great Slave Lake because of the paucity of good gravel and other suitable highway construction materials.

At the same time the city is surrounded by vast quantities of waste tailings for which there is a shortage of disposal space.

It is with a view to solving all of these problems with one product that we have embarked on a research programme to test a new product which we will call "Mad Dog Cement".

The intent of the new product is to bind up the undesirable waste products in a manner useful for trench backfill and road subbase which will preserve existing ground temperatures and displace the granular materials.

2.0 FOAMED SOIL CEMENT

Historically, soil cement has been used for road base where suitable aggregates are not available. As a general rule the criticism of soil cement has been that it does not withstand freeze-thaw action; that it does not have adequate durability.

Many studies have been conducted through 1960-1986 to determine the effect of one or other chemical admixture on the strength and durability of soil cement with varying success. At least one study suggests addition of 1% sodium sulphate improves strength, durability and frost resistance but these have not been significant or conclusive.

Recently, foamed products have come on the market and are used for light weight concrete. Mad Dog Cement (MDC)* is a lightweight cellular concrete that owes its distinctive properties to a multitude of macroscopic, non-interconnecting air cells uniformly distributed throughout the mass. These cells may account for up to 90 percent of the total volume. Various gases may be used to achieve the expansion desired. Colorado School of Mines Research Institute (CSMRI) has investigated carbon dioxide, nitrogen and compressed air singularly, as well as combinations of these gases. Emphasis has been placed on air as the expansion matrix for reasons of economics.

MDC consists of aggregate, portland cement, water and proprietary organic admixtures. The admixture components are responsible for the expansion of the cement slurry. The end chemical products of the hydrated cement are neither affected nor altered, thus the chemistry of conventional cement and MDC are the same. The only change is physical in nature and is limited to the enlargement of gaseous bubbles within the cementitious matrix. CSMRI has developed a family of reagents which impart highly stable and uniform-sized vesicles which permit a competent homogenous product to develop upon curing.

The mixing system required to assimilate the foam into the slurry can be either a rotary (batch) or incline (continuous) system. The MDC density can be controlled within a specific gravity range of 0.3 to 2.3. The resultant product can then be placed by using conventional positive displacement piston-type pumps. Tests conducted on several MDC slurries showed that significant pumping distances (in excess of 1,000 ft.) can be achieved.

2.1 KEY FEATURES OF MDC

The key features of MDC are:

- Heat resistant
- Variable Compressive Strengths
- Easily Produced and Pumped
- Non-toxic

The research conducted to date by CSMRI and others indicates that MDC is an excellent product for extinguishing underground coal fires and providing subsidence control. These properties suggest that MDC might do very well in an application to supplant granular fill material and preserve permafrost.

3.0 LABORATORY TESTS

3.1 Samples:

Samples were prepared by Goodson & Associates Inc. of Denver, Colorado at the request of Thurber Engineering Ltd., Yellowknife. Twenty-seven specimens were made, all of which have four constituents; water, portland cement, Sammy's sand, and air. Four levels of expansion were provided to each of two different original mix designs. The two ratios of cement to sand were 8.7 and 13.2% and the four expansion levels were 15%, 28%, 50% and 78%. Densities of the specimen's are given at Table I.

Two samples of each mix were subjected to freeze-thaw cycling and the remainder have been saved for future strength testing of the original mixes.

After initial weights and measurements, the specimens were soaked and put through 12 cycles of freezing and thawing, generally in accord with ASTM. For each cycle the samples were soaked for several hours, and placed in a home freezer at -14 degrees C. in a saturated, surface dry condition.

They were allowed to freeze for 24 hours, thawed, brushed and reweighed to determine loss of material, if any.

4.0 TEST RESULTS

In general the specimen densities were observed to increase 10% to 20% over the first 5 or 6 cycles and then stabilized. Clearly they were not fully saturated during the first few cycles.

Several days following the last freezing cycle the weight of each specimen was greater than the original weight indicating they were not thoroughly dry following the last cycle.

Evidently the weight loss resulting from the cyclical freezing was not significant. (Table 1).

There is no evidence of cracking or spalling and no significant loss of material from any of the specimens.

5.0 CONCLUSION

The results of the testing to date have been very gratifying. There has been no significant deterioration of any of the specimens at the compositions tested.

Following a series of strength tests on the present samples, we expect that the next steps will be to:

- (a) reduce the cement content and hold the maximum expansion; and repeat the above tests to determine the most economical product which will be durable.
- (b) replace the sand with mine tailings;
- (c) test the leanest surviving mix for heat flow resistance;
- (d) go to a field trial during the summer of 1991;

The most appropriate test section will be located in Yellowknife over a deep deposit of ice rich permafrost and will be fully instrumented with thermistors.

ACKNOWLEDGEMENTS

I would like to acknowledge the financial support of the Science Institute of the Northwest Territories. Mr. Craig d'Entremont, in particular, deserves our thanks for his continuing enthusiastic encouragement of this project. We also wish to thank Goodson and Associates Inc. of Denver for support, patience and provision of the test specimens.

TABLE 1

FREEZE - THAW TEST RESULTS

SPECIMEN	CEMENT/ SAND	CEMENT/ WATER	% EXPANSION	INITIAL WT (GMS)	DENSITY GM/CC	FINAL WT (GMS)*
1	.09	.5	14.4	321.8	1.287	326.7
2	.09	.5	14.4	315.8	1.244	320.1
5	.09	.5	28.0	294.3	1.170	298.4
6	.09	.5	28.0	289.9	1.164	293.6
9	.09	.5	43.3	257.5	1.024	260.4
10	.09	.5	43.3	255.5	1.016	257.8
13	.13	.76	15.4	332.0	1.320	338.3
14	.13	.76	15.4	326.9	1.300	333.4
17	.13	.76	27.6	296.7	1.191	302.8
18	.13	.76	27.6	295.8	1.199	302.1
21	.13	.76	49.6	244.3	0.991	249.0
22	.13	.76	49.6	252.9	1.006	257.6
25	.13	.76	77.8	208.3	0.836	211.8
26	.13	.76	77.8	199.3	0.800	202.2

*** after 12 freeze - thaw cycles**

**Solid Waste Management Study
for the City of Yellowknife (Phase II)**

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Municipal Planning Engineers

SOLID WASTE MANAGEMENT STUDY FOR THE CITY OF YELLOWKNIFE (PHASE II)

This presentation is a continuation of the work completed on phase I of the project and presented at the Municipal Planning Engineers conference in December 1989.

During Phase I, Stanley Associates was to evaluate all the options available to the City of Yellowknife for waste management. This required determining the amount and nature of waste material generated in the City.

The amount of material being hauled to the dump was calculated by two methods.

- a) Weighing of the trucks that are operated under contract with the City to collect and dispose waste from the City.
- b) On site survey/check list of vehicles delivering waste directly to the dump. The nature of waste material was identified as municipal, construction debris, waste fill from excavations and scrap metal. The quantities of material were estimated for trucks and cars delivering waste.

Using the above data, and comparing this to surveys done in other areas such as Edmonton and Iqaluit, the following breakdown of waste materials was derived.

<u>Waste type</u>	<u>Percentage of Waste Stream</u>
Paper/Cardboard	33
Glass	4
Metals	8
Plastics	10
Wood	4
Organics	25
Miscellaneous	16

A total annual weight of waste delivered to the dump was estimated at 10,550 tonnes.

Following the determination of the amount and nature of waste material in the Yellowknife area, a "shopping list" of waste management options was prepared with some initial evaluations of the pros and cons of each.

This shopping list includes 10 options as shown below:

1. **Existing Modified Landfill Operations** - continued use of the existing site and continued use of uncontrolled waste burning as a means of volume reduction and lessening of cover material requirements.
2. **Sanitary Landfill Operations at the Existing Site** - conversion of the existing site to a sanitary landfill.
3. **Sanitary Landfill Operations at a New Site** - sanitary landfill operations at a site located 8 km or more from the airport.

4. **Shredding and Shred-Fill** - new site for shred-fill operations, continued use of existing site for construction/demolition debris and large scrap steel waste.
5. **Baling and Bale-Fill** - new balefill site with continued use of existing site for construction/demolition debris and large scrap steel waste.
6. **Curbside Recycling** - citywide curbside recycling program in conjunction with sanitary landfill operation.
7. **Drop Off Recycling** - establishment of a drop off depot for recycling material in conjunction with sanitary landfill operations.
8. **Incineration Without Waste Heat Recovery.**
9. **Incineration With Waste Heat Recovery for District Heating.**
10. **Incineration With Power Generation.**

All of the above options were presented to City Council and the public in several open meetings. Following the meetings, the City of Yellowknife instructed Stanley to further study and develop the following options:

1. **Sanitary Landfill Operations at the Existing Site** - conversion of the existing site to a sanitary landfill.
2. **Sanitary Landfill Operations at a New Site** - sanitary landfill operations at a site located 8 km or more from the airport.
3. **Baling and Bale-Fill** - new balefill site with continued use of existing site for construction/demolition debris and large scrap steel waste.
4. **Curbside Recycling** - citywide curbside recycling program in conjunction with sanitary landfill operation.

The following is a brief discussion of the work performed in developing the options above.

1. Sanitary Landfill Operations at the Existing Site

For the conversion of the existing site, Stanley prepared a manual to assist the City's forces in operating the site as a sanitary landfill. This manual showed the present site broken down into a series of cells which would be operated until they reached a certain elevation. Separating the cells would be windrows of granular material to be used for covering the waste at the end of a working day or when the depth of waste reached 3 meters. Through a series of drawings, the number of cells was reduced until the landfill reached a final contour where a capping of granular material could be placed over the top to complete the closing of the existing site. This site could then be used for open space for recreation use in future planning.

The primary goals of the conversion was to change the existing method of operation to reduce the size of the working face of waste exposed, increase the amount of compaction by heavy equipment and increase the frequency of covering with granular material.

As well, separate areas would be established for the dumping of construction waste to allow recycling. The dumping of scrap steel waste would be eliminated at this site.

2. Sanitary Landfill Operations at a New Site

A new site was to be found to be developed as a sanitary landfill. Due to some regulations/guidelines developed by Transport Canada a collection facility for waste material cannot be sited within an 8 km radius of the center of the airport. This 8 km radius regulation has been developed in conjunction with trying to eliminate bird strikes at airports.

This eliminated several potential sites located within the City limits. One potential site remaining was what is referred to as the Hay Lake site. It is located on the access road to Dettah. It is a suitable location as it is very wide open, has cover material on the site and appeared to consist of a clayey material which would act as liner or barrier to leachate migration. Access to the site is across the Yellowknife bridge which is a one lane bridge. The bridge can take the loading of the trucks but as it is one lane, the constant truck traffic would restrict traffic. There is also a concern that the residents of Dettah would oppose the development of a large landfill so close to their community.

On the advice of the City, a site to the west of Yellowknife was to be investigated in the area of the sewage lagoon to have all the "undesirables" in one area. At the time of this presentation, a site has been identified, and negotiations are proceeding to secure the site for use as a landfill. At the request of the City, this location cannot be discussed.

3. Baling and Bale-Fill

The work involved with the development of this option awaits the outcome of negotiations for the new landfill site.

4. Curbside Recycling

The development of this option involves preparing cost estimates to demonstrate the initial capital costs and the annual operating costs for a City wide recycling program. These would then be offset against the revenue generated by the recycling to determine the net annual subsidy by the City to maintain the program.

The recycling program would include aluminum and steel cans, glass, newsprint and cardboard. These materials are highly visible in the Yellowknife waste stream and are easily segregated. Long term markets are expected for all of these materials but presently aluminum cans are the only economically viable recyclable commodity.

The capital costs include:

ITEM	COST \$
Blue boxes	17,100
Modified flat bed truck to collect blue boxes	35,000
Forklift	30,000
Can densifier	35,000
Baler	30,000
Scale	10,000
8 self tipping bins to store materials prior to processing	24,000
Palletizing equipment	<u>20,000</u>
Sub Total	201,100
15% Contingency and Engineering	<u>30,165</u>
TOTAL	231,265
Amortized over 15 years at 12% interest p.a.	33,950 p.a.

The Operating Costs include:

ITEM	COST PER YEAR \$
Building Lease	36,000
Collection Vehicle O&M	25,000
Other O & M costs including materials	12,000
Two full time personnel (driver, equipment operator)	65,000
Part-time labourer	15,000
Part time secretarial and bookkeeping	<u>15,000</u>
Sub Total	168,000
15% Contingency	25,200
TOTAL	193,200

The revenue generated from the sale of recycled materials is illustrated as shown below

Material	Total Quantity Recovered (Tonnes)	Value in Edmonton \$	Revenue
Newsprint	200	(57)	(11,400)
Cardboard	61	(42)	(2,562)
Steel	43	(37)	(1,591)
Aluminum	60	1,133	67,980
Glass	70	(52)	(2,640)
TOTAL	434		48,787

Thus, the costs to the City of Yellowknife is summarized as follows:

Capital Costs per year	\$ 33,950
Operating Costs per year	<u>193,200</u>
Total Costs per year	227,150
Revenue from sale of Material	48,787
Net Cost	178,363

**NIVEN LAKE ENVIRONMENTAL SURVEY
PLANNING ENGINEER'S CONFERENCE BRIEF**

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1. INTRODUCTION

Niven Lake is a small lake within the boundaries of Yellowknife which was used in the past for the storage and treatment of municipal wastewater. Due to the proximity of the Niven Lake area to the City core, there is interest in developing the area or providing additional recreational space for City residents.

The Lake occupies approximately 9 hectares located to the North of the City core with a maximum water depth of approximately 1.2m. The City of Yellowknife discharged sewage into Niven Lake for approximately thirty years until 1981. Engineering improvements to the lake over it's life as a lagoon included the construction of a primary settling pond and a discharge control weir.

The use of the lake for municipal wastewater treatment was discontinued with the commissioning of the Fiddler Lake Sewage Lagoon system in 1981. Since that time, no sewage has been discharged into the lake and the area has been left relatively undisturbed.

The City commissioned Ferguson Simek Clark to undertake an environmental survey to determine the existing quality of soil and water in the Niven Lake area. This paper summarizes the results of the study, presents some alternatives currently being considered for remediation of the site and discuss implications for planning lagoon systems for other northern communities.

2. PROGRAM SUMMARY

The field program was undertaken from January to October 1990 and included both winter and spring sampling sessions. Water, sediment, sediment leachates and microbiology were analyzed from the Niven Lake area with additional samples collected from Frame Lake and Yellowknife Bay to provide a comparative basis for results.

The accompanying figures depict the project site and sampling station locations.

3. PROGRAM RESULTS

3.1 WATER

With the exception of nutrient and arsenic levels, analytical results indicate that the samples collected meet CCREM¹ guidelines for recreational use and protection of aquatic life within the range of variance expected for the parameters analyzed.

Arsenic results for Niven and Frame Lakes are approximately ten times the maximum recommended levels from CCREM guidelines for drinking water and protection of aquatic life. Elevated arsenic levels in the Yellowknife area have been recorded previously and have been attributed to the former use of smelters by local gold mines.

Existing literature² indicates that similar arsenic levels exist in local water bodies at the present. Historic values of up to 12,600 ug/L have been reported in surface waters in the Yellowknife Area. The presence of arsenic in upstream waters is further evidenced by the results of the spring water sampling at the inflow to Niven Lake.

From these data, it is concluded that although arsenic values are in excess of recommended guidelines, the levels are equivalent to background concentrations expected in this area.

Results indicate that the Niven Lake waters exhibit nutrient values considerably above adjacent water bodies. The high nutrient values can be linked to the high organic content of the lake bed sediments and is consistent with use of the lake as a sewage lagoon.

High ammonia levels are of concern due to the toxicity level of this compound to freshwater organisms. Ammonia is considered toxic at concentrations of approximately 2 parts per million. Water samples from Niven Lake displayed ammonia levels from 4.5 to 4.8 parts per million.

1 Canadian Council of Resource and Environment Ministers,
Canadian Water Quality Guidelines, March 1987

2 Yellowknife Bay/ Back Bay Water Quality Study, Department of Indian and Northern Affairs (currently unreleased)

National Water Quality Data Bank. Water Quality Branch, Inland Waters Directorate, Environment Canada. 1977

Task Force on Arsenic. Final Report. Canadian Public Health Association. Yellowknife Northwest Territories. 1979

The high nutrient levels are also indicators of possible organic pollution and annoxic (no oxygen) conditions. Annoxic conditions were confirmed by low dissolved oxygen levels and noxious odours emitted by lake bed sediments.

3.2 SEDIMENT SAMPLE RESULTS

Microbiological results from Niven Lake were generally negative for all samples except in the area of the primary lagoon. The presence of indicator organisms in the primary cell indicate the possibility of pathogenic organisms in this area.

Analytical results for arsenic, cadmium, copper, mercury and zinc levels were generally in excess of Ontario Ministry of the Environment guidelines for acceptable levels of contaminants at decommissioned sites. Metal concentrations in the area of the primary cell were generally higher than the rest of Niven Lake and all Niven Lake samples were higher than samples collected from Frame Lake and Yellowknife Bay.

The metal concentrations in Niven Lake are slightly lower when compared to other small municipal sewage lagoons. Elevated concentrations are expected in a sludge from a municipal treatment system since the lagoon will remove some of the metals from the sewage discharge with the removal of total suspended solids.

All sediment locations sampled, except for Yellowknife Bay off School Draw, displayed arsenic levels in excess of levels recommended by the MOE guidelines. As for water samples, a possible source for arsenic may be attributable to the former use of smelters by local gold mines.

The sediment samples displayed loss on ignition (LOI) values of 40 to 60%. This parameter indicates a very high organic content in the lake bed sediments. These values in conjunction with elevated nutrient and oxygen demand values can be interpreted to indicate that there has not been significant decomposition of the original material deposited. The lake bed sediments are still sewage sludge. Annoxic conditions result in relatively slow rates of degradation by microorganisms.

3.3 SEDIMENT LEACHATE RESULTS

Sediment leachate was analyzed for eight samples collected from Niven Lake and four samples from the primary cell. The leachate analysis provides additional information on composition and quality of the sediments as well as the possibility for contaminant migration.

As for sediment analysis, results indicate mild contamination by the heavy metals arsenic, cadmium, copper and zinc.

It appears that the composition of mercury in the sediments is in a relatively stable form and will not be made readily available to the environment. Other heavy metals present in the soils are relatively stable under present conditions.

4.0 IMPACT EVALUATION

Niven Lake poses little risk to the environment if left "as-is". It would be expected that a significant amount of ammonia present in the waters would be volatilized by mechanical mixing of effluent prior to discharge in Back Bay. This evaluation would need to be confirmed by water sampling at the conflux of the discharge stream and Back Bay.

The impact of this site on public health is considered equivalent to having an operating sewage treatment system without the presence of pathogenic organisms in the water.

Development or recreational use of this area would require some form of remediation to stabilize the sludges.

5.0 REMEDIATION ALTERNATIVES

Remediation alternatives are presently being considered for restoration of the site. The primary objectives of remedial measures are to stabilize sludges and prevent any migration of contaminants to the environment. The following provides a brief listing of some techniques which may have potential at the Niven Lake site.

5.1 LEAVE "As-Is"

As noted earlier, this option would preempt development or recreational use of the area.

5.2 INFILLING

It may be possible to infill the area to isolate the sewage sludges from the environment. This alternative may cause problems due to migration of odours from the decomposing organic material and potential for migration of contaminants with groundwater.

A significant amount of fill would be required due to the large area and relatively soft soils.

5.3 EXCAVATION AND LIME TREATMENT

It is possible to excavate or dredge the sludges, dewater and treat with lime to lower the potential for leaching of contaminants. Disposal would be to the municipal landfill or other solid waste disposal area where the material would be capped with clean fill to reduce water migration through the material.

This option would require collection and monitoring of runoff from the disposal area. Treatment of leachates would be required if contaminant levels were found to be excessive.

This is a common practice for sludge disposal in other municipalities.

5.4 INCINERATION AND LIME TREATMENT

An alternative to reduce sludge volume would be to incinerate the material prior to lime treatment and disposal at a landfill. Removal of putrescible material would also eliminate problems with smell and reduce leaching potential and it may be possible to use the resulting product as fill at the site.

This remedial method may not be applicable due to fuel costs as well as concerns regarding stack emissions.

5.5 DCR TECHNOLOGY

DCR (Dispersion by Chemical Reaction) remediation techniques use a cement combined with chemicals which disperse the cement throughout the soil matrix to provide complete encapsulation of any contaminants.

The resulting product is a dry, stable material suitable for use as fill for road embankments or other civil projects. It may be possible to use the fill for improvements in the Niven Lake Area.

Pretreatment including dewatering is required for this option.

The primary advantage of this option is the cost recovery potential of the products.

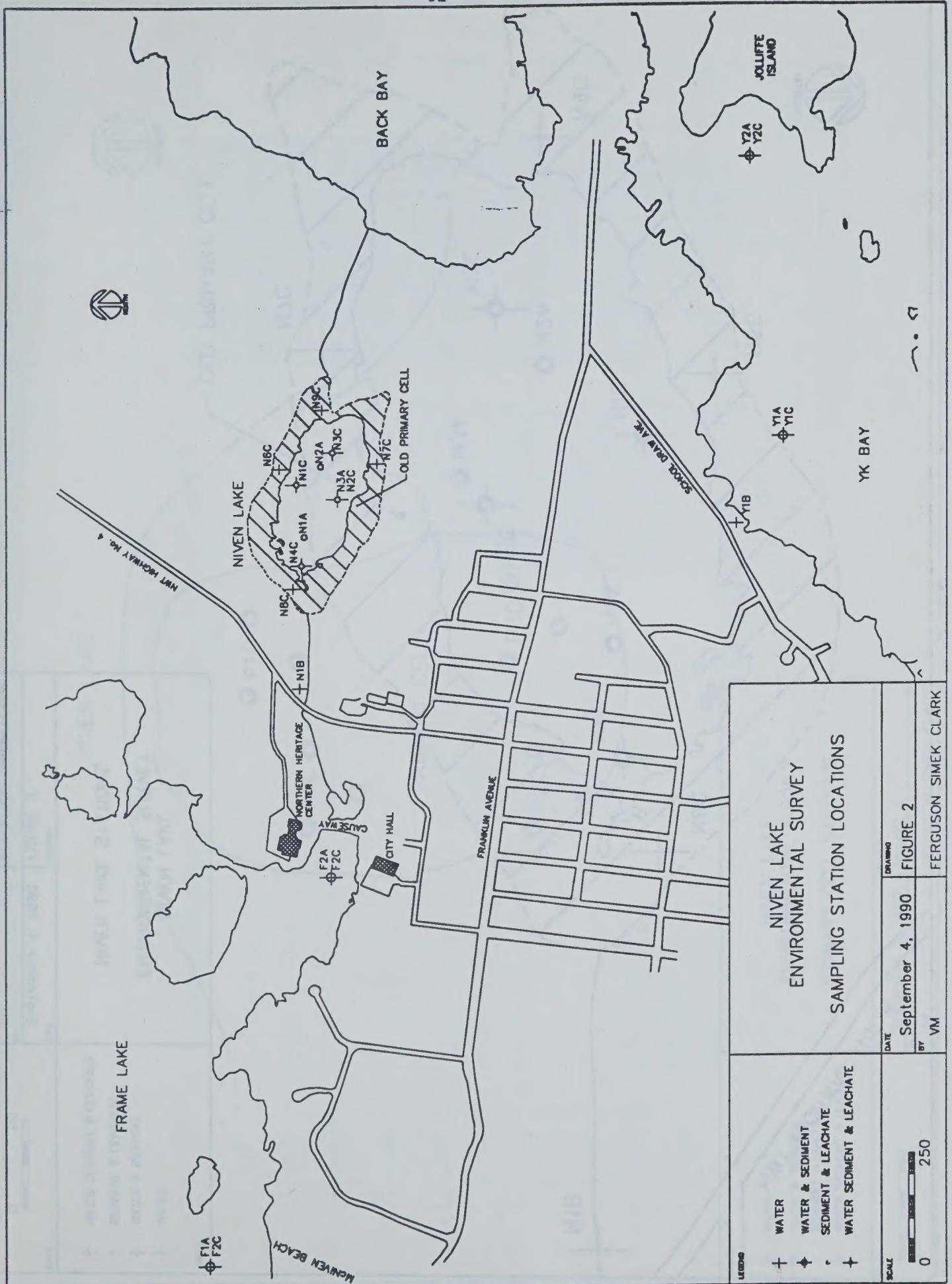
6.0 PLANNING IMPLICATIONS

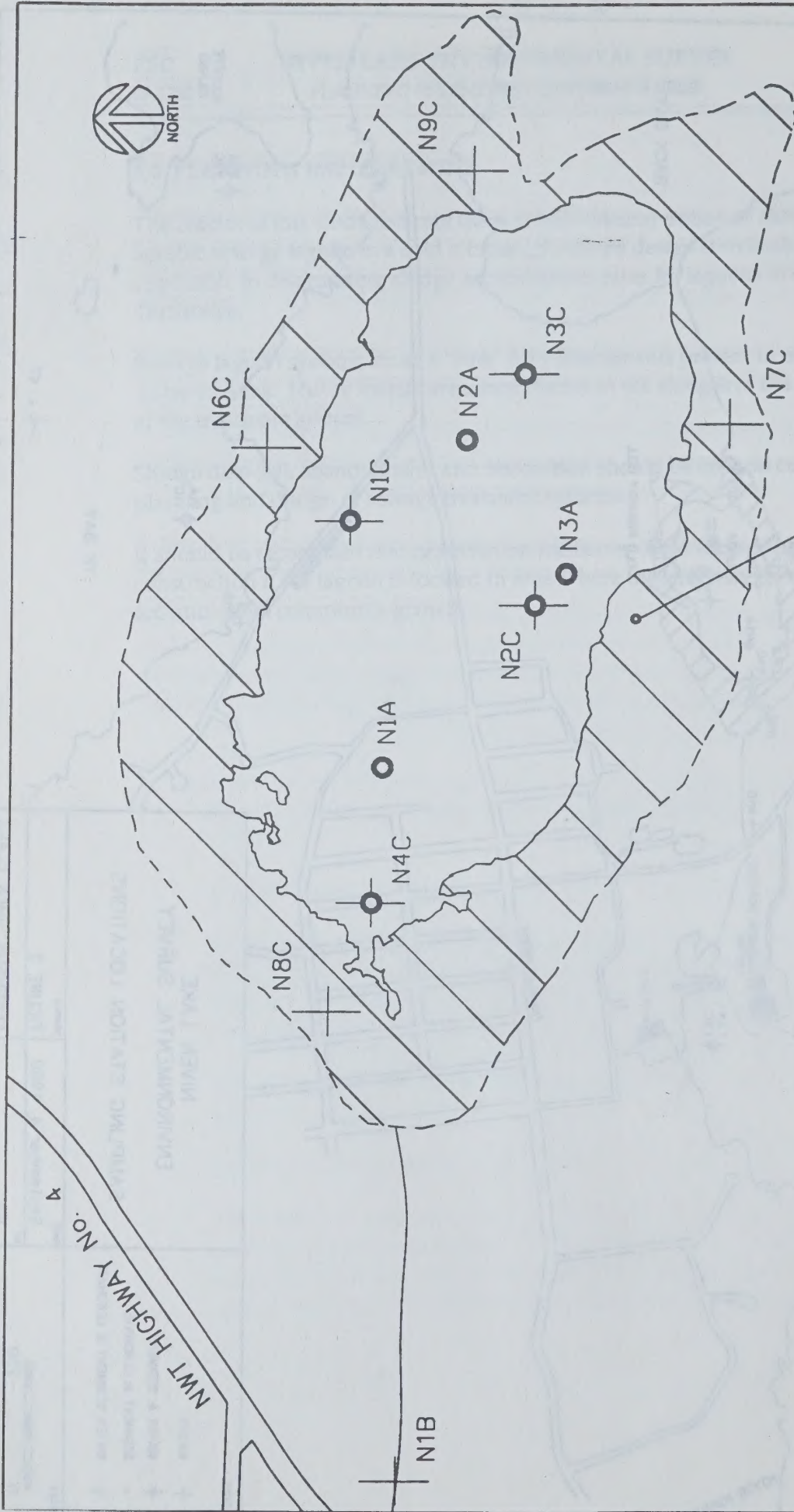
The results of this study indicate there is little decomposition of sludge materials in an aerobic sewage lagoon in a cold climate. Southern design standards may not be applicable in determining sludge accumulation rates for lagoons in the Northwest Territories.

Sewage lagoon systems act as a "sink" for contaminants present in municipal waste water streams. Heavy metals are concentrated in the sludges of the lagoon over the life of the treatment system.

Sludge disposal, abandonment and restoration should be integral components in the planning and design of sewage treatment systems.

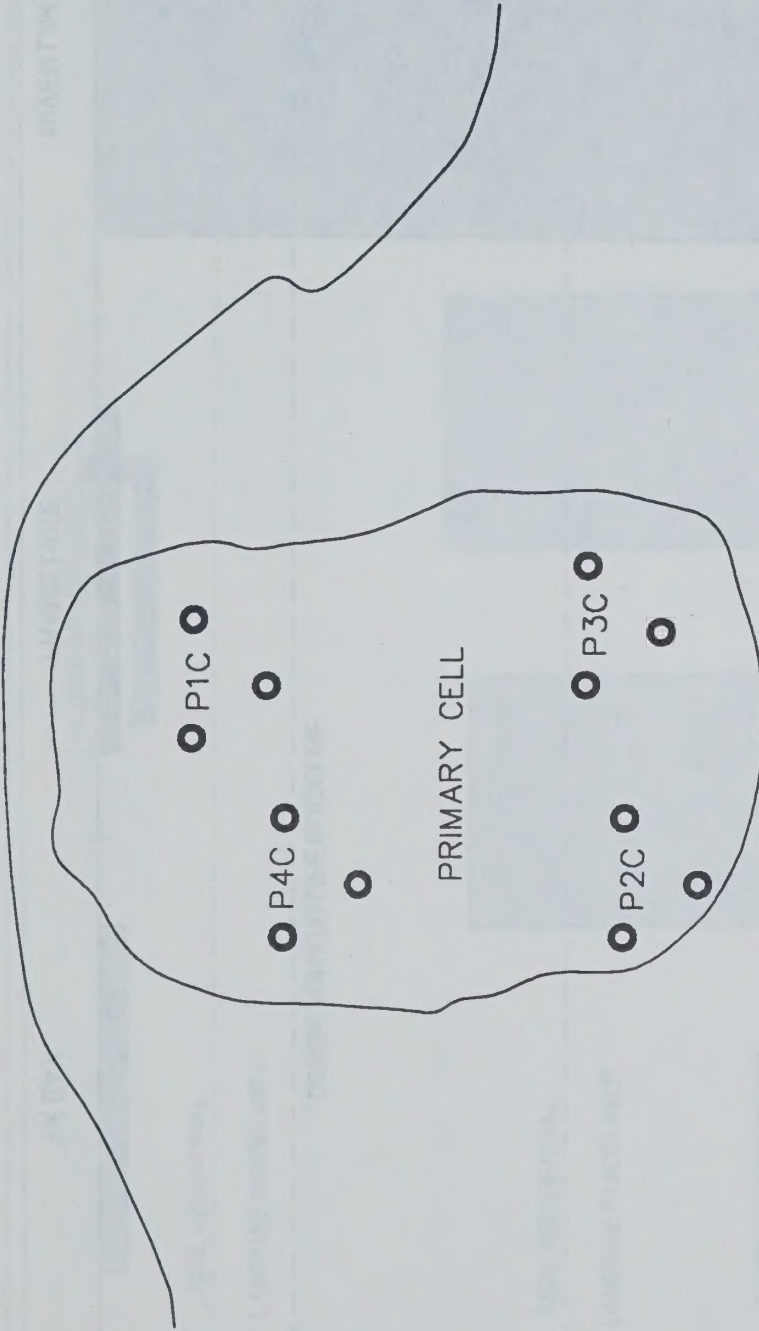
It should be recognized that remediation measures could exceed the initial cost of construction if the lagoon is located in area where the land may be required to accommodate community growth.





NIVEN LAKE ENVIRONMENTAL SURVEY NIVEN LAKE STATIONS	
+ WATER ⊕ WATER & SEDIMENT ⊙ SEDIMENT & LEACHATE ⊕ WATER SEDIMENT & LEACHATE	DATE September 4, 1990 BY VM
SCALE 0 50	DRAWING FIGURE 3 FERGUSON SIMEK CLARK

NIVEN LAKE



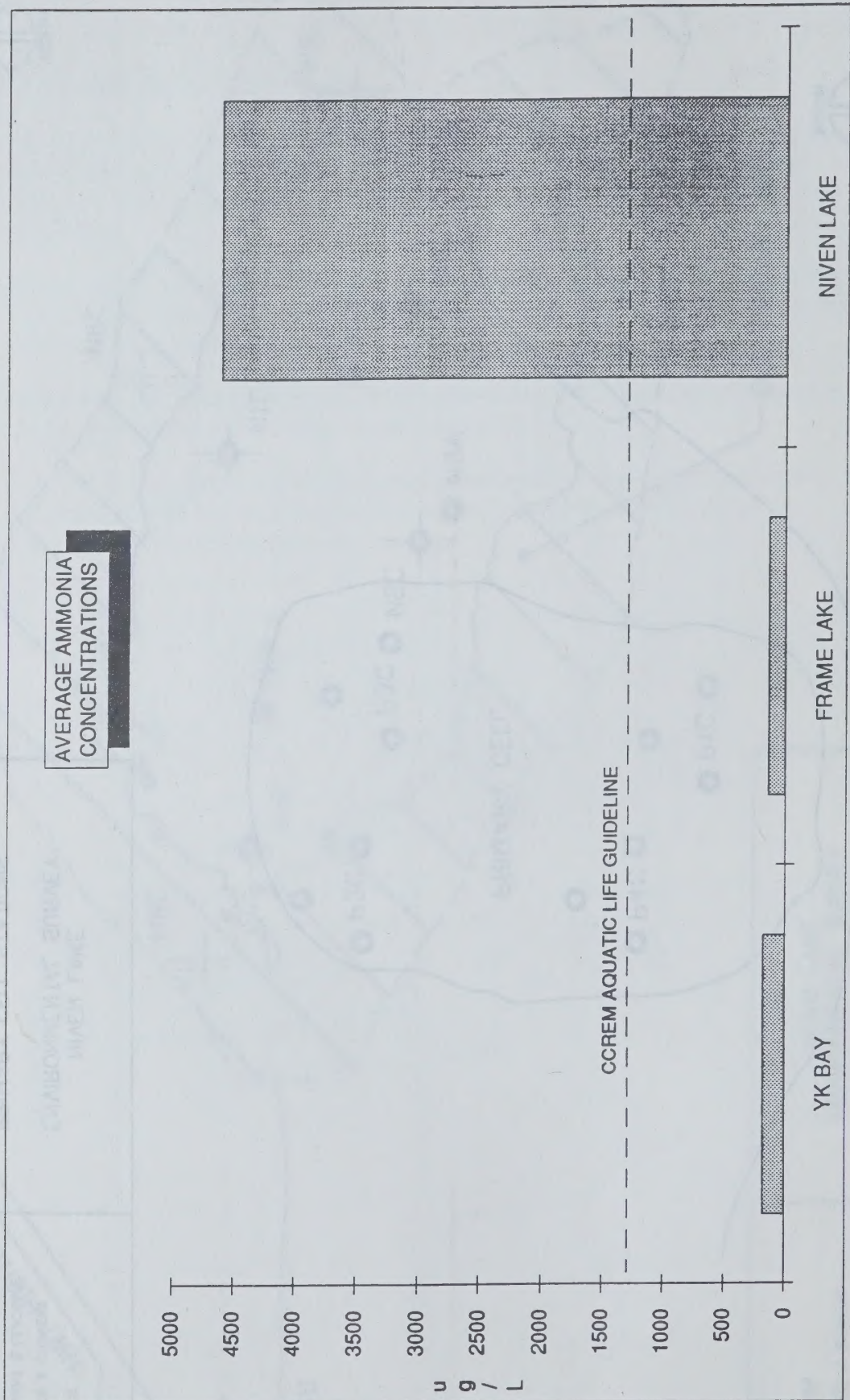
NIVEN LAKE ENVIRONMENTAL SURVEY PRIMARY CELL STATIONS		DATE	DRAWING
		September 4, 1990	FIGURE 4
		BY VM	FERGUSON SIMEK CLARK

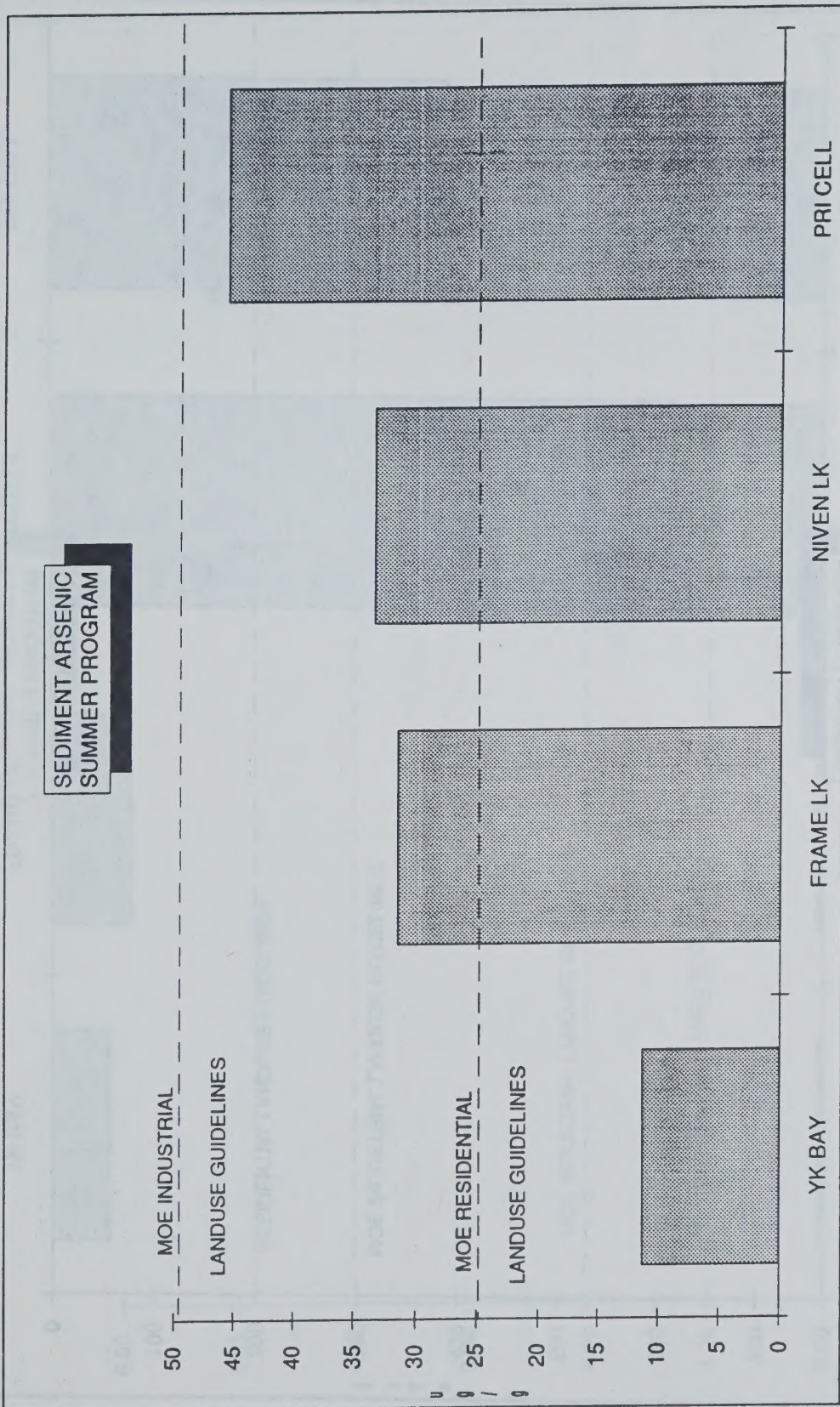
LEGEND

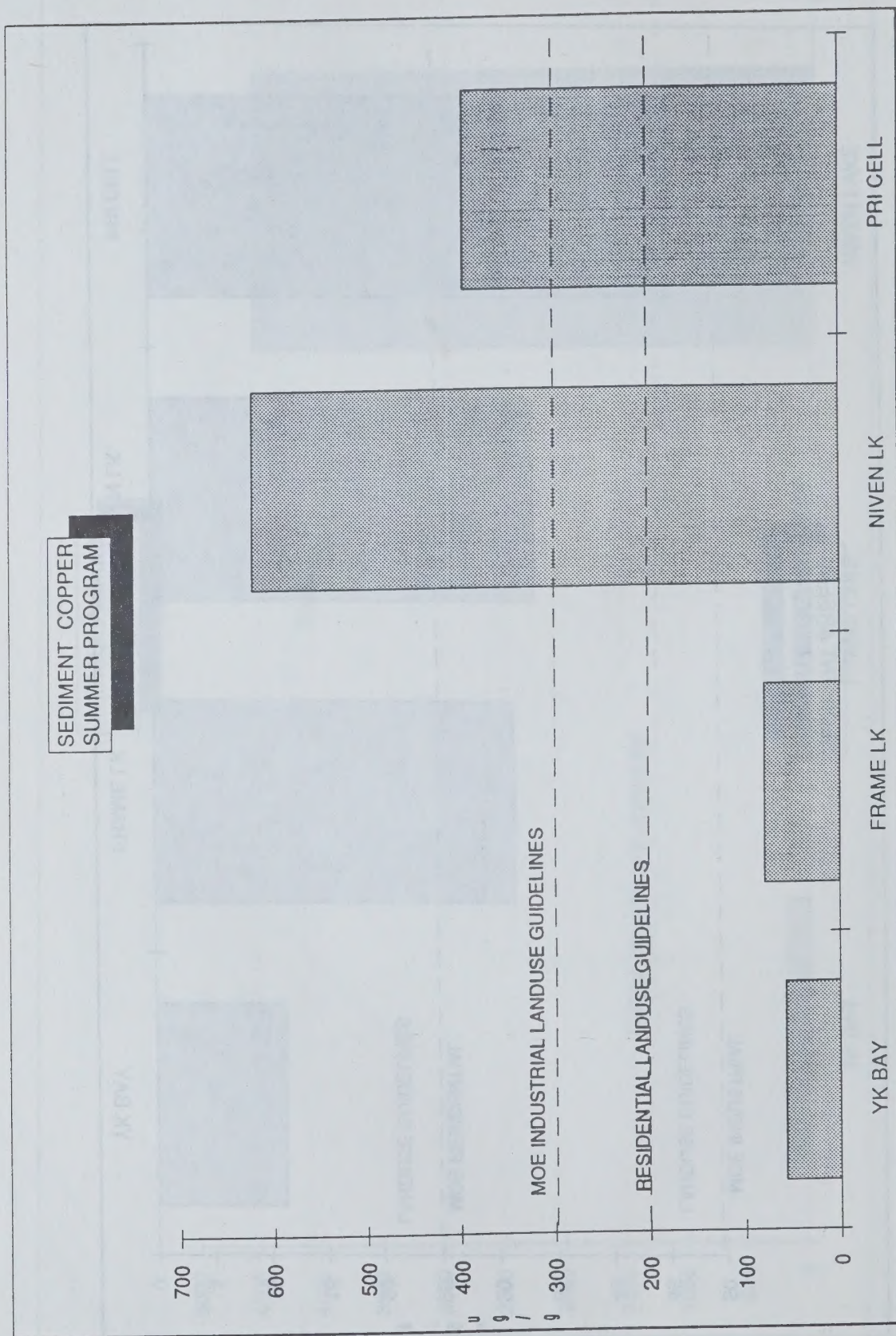
- + WATER
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SCALE

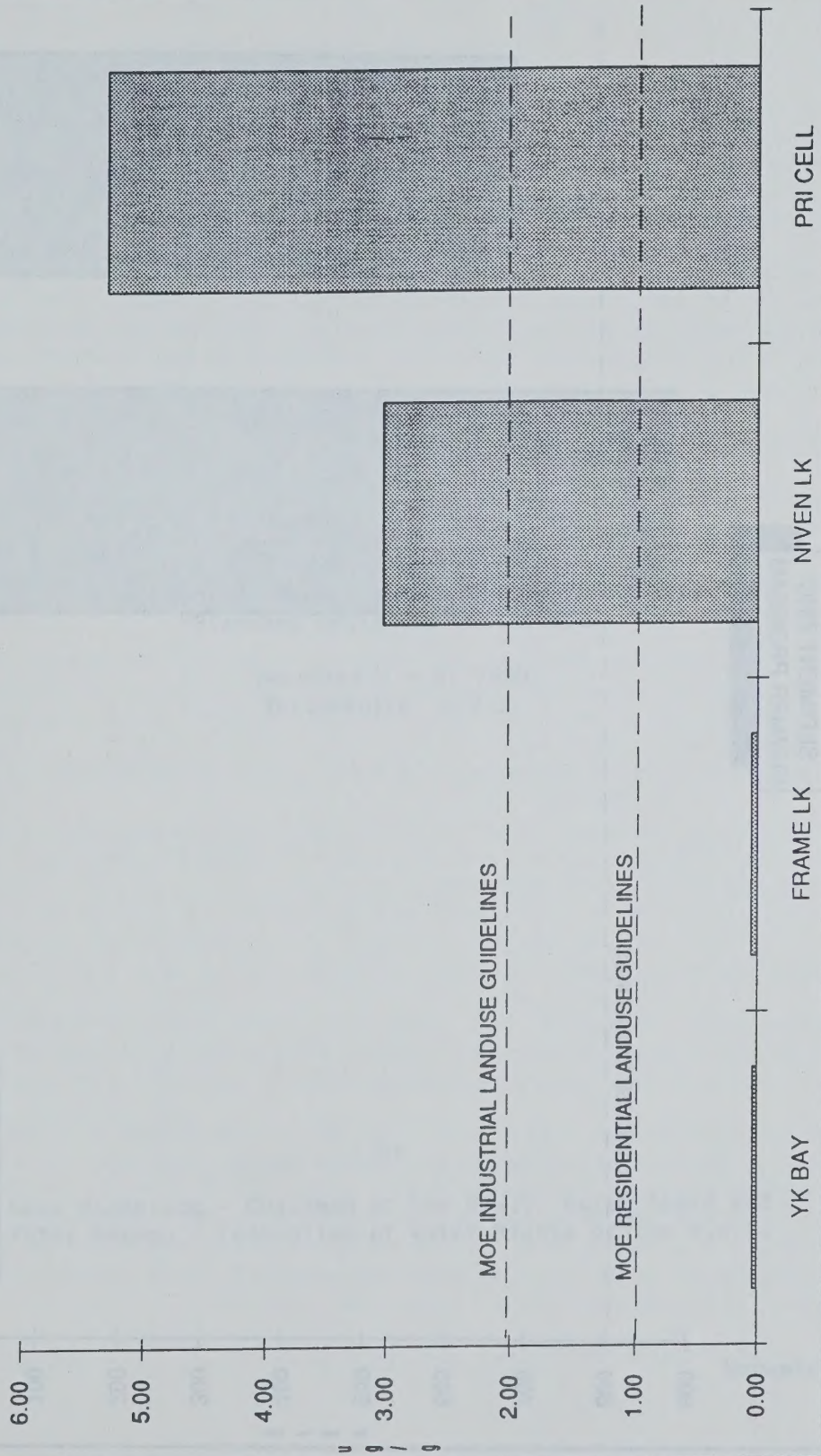


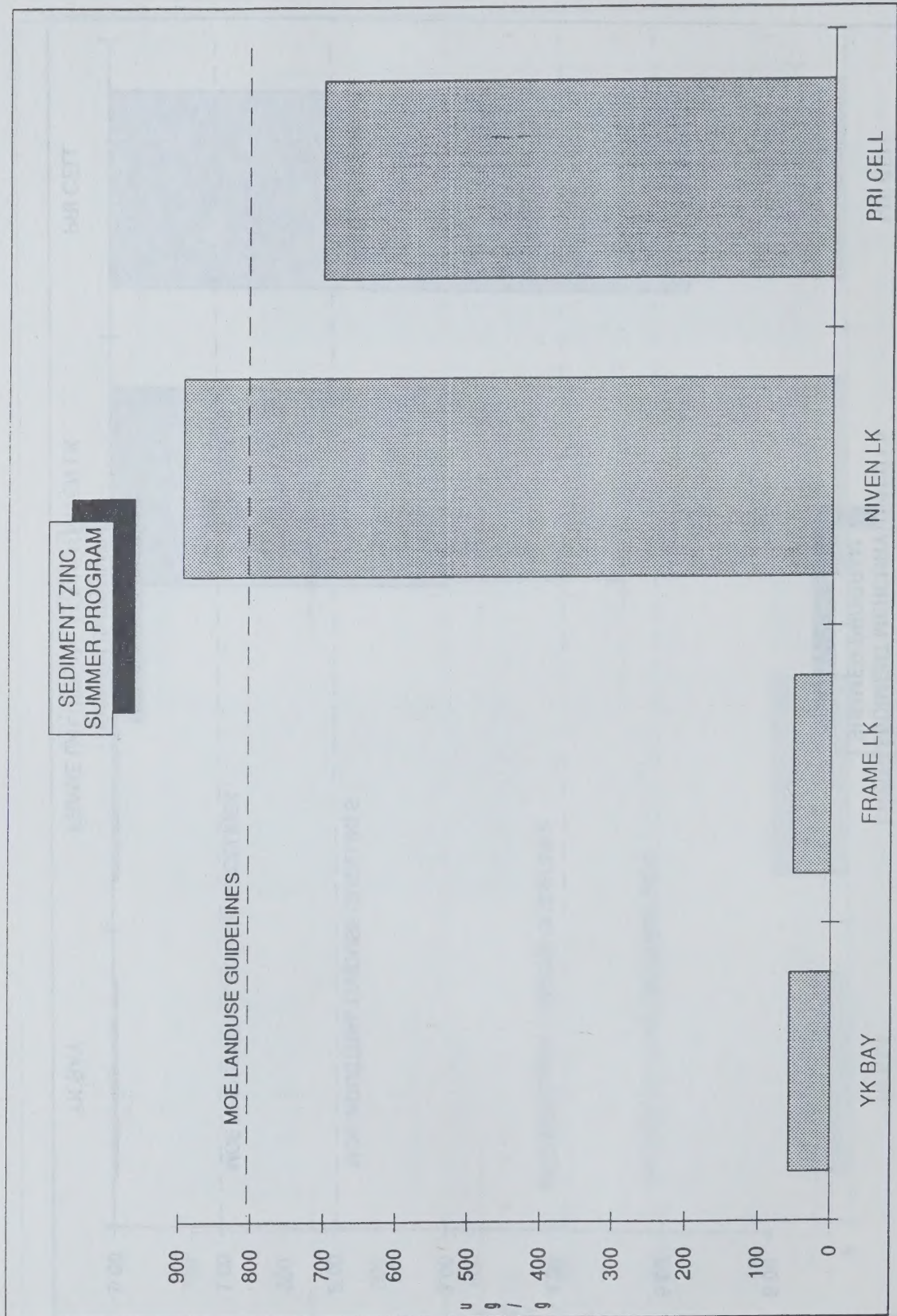






SEDIMENT MERCURY
SUMMER PROGRAM





THE MACA/WATER BOARD INTERFACE

Presentation prepared for the
Department of Municipal and Community Affairs
"Planning Engineers Conference"

December 4 - 6, 1990
Yellowknife, N.W.T.

by

Dave Nickerson - Chairman of the N.W.T. Water Board and
Peter Bannon - Controller of Water Rights of the N.W.T.

November 1990

THE MACA/WATER BOARD INTERFACE

Under the Northern Inland Waters Act any water use or deposition of waste for industrial, municipal or other purposes requires a licence issued by the N.W.T. Water Board and approved by the Minister of Indian Affairs and Northern Development.

The purpose of this presentation is to address some of the latest developments as they affect municipal and related type licences. The authors would also like to encourage the exchange of plans between MACA and the Board's Technical Advisory Committee at early stages in the design process.

Revised Municipal Effluent Guidelines

This publication is provided as a service to those operating and planning municipal waste systems. Acting on the advice of its Technical Advisory Committee and a special committee established for the purpose which included MACA representation the guidelines have recently been revised. The principle changes between these new guidelines and the existing ones are:

- I. The updating of effluent quality guidelines based on empirical data collected since the publication of the original guidelines.
- II. Replacement of Total Coliforms with Fecal Coliforms as an effluent quality guideline.
- III. Establishing differing effluent quality guidelines for summer and winter discharges.
- IV. Noting the undesirability of disinfecting waste water by chlorination.
- V. The addition of the requirement for proper operation and maintenance plans for waste treatment facilities.

Hydrostatic Testing

Hydrostatic testing of fuel tanks has caused problems over the last couple of years mainly because contractors were unaware of the need to obtain a licence, and the lengthy period of time it takes to issue a licence.

If the quantity of water used does not exceed 50,000 gals/day and there is to be no waste disposal then a licence is not required. Unfortunately it is often inexpedient to conduct tests using such low daily volumes. The Board has reserved judgement on whether water used for testing new tanks is to be considered a waste, but the discharge from old tanks which is likely to be contaminated with hydrocarbons and possibly heavy metals is considered a waste, and consequently a licence is required.

Because the Act requires that the opportunity be given for interventions and a public hearing before a licence can be issued, it is seldom possible to process a licence in less than four months and applicants should preferably allow six months.

Licences usually stipulate that the discharge from a tank ought not to be put back directly into a water course, but rather held in a location where separation can take place and the water quality ascertained prior to return to the environment. Apparently these terms have not always been complied with by all of the contractors involved.

Possible Amendments to the Northern Inland Waters Act

Consultations have been going on over the last several years with a view to improving the current Northern Inland Waters Act. Delay has been caused largely by the placer situation in the Yukon. Our understanding is that most of the outstanding issues have now been resolved but whether or not the government intends to introduce the proposed Northwest Territories Inland Waters Act into Parliament is not really known. Since, once the land claims are settled a new system of water management and regulation will be put into effect, the government may well feel that it is not worth the parliamentary time to deal with legislation which will only last a couple of years or so. Even if it does not go ahead, the work will not have been completely wasted as many of the good ideas could be incorporated into the water management legislation contemplated by the land claims agreements in principle.

As far as municipalities are concerned the most pertinent proposed change is to be dealt with by regulations made under the Act. The Board will be able to issue "B" licences to the smaller communities. "A" licences will correspond to current licences in that they require the opportunity for a public hearing and the Minister's signature on the licence but, "B" licences will normally not require a public hearing nor the Minister's signature. It will therefore be much easier and quicker to issue them to the applicant municipality.

The proposed criteria for distinguishing between the various types of municipal licences are:

I. Based on Water Consumption

- a) No Licence required. An unincorporated settlement and $\leq 50\text{m}^3/\text{day}$.
- b) "B" Licence An incorporated settlement or $>50\text{m}^3/\text{day}$
and $\leq 200\text{m}^3/\text{day}$
- c) "A" Licence An incorporated settlement and $>200\text{m}^3/\text{day}$.

II. Based on Waste Deposition

- a) No Licence required. An unincorporated settlement with population ≤ 50 ; municipal waste not discharged directly to a water body and; meets Public Health Act (N.W.T.)
- b) "B" Licence An incorporated settlement with population between 50 and 500 or; waste is discharged directly to a water body or; waste disposal does not meet the Public Health Act
- c) "A" Licence An incorporated settlement with population > 500

Water Management after Land Claims

Both the TFN and Dene/Metis Agreements in Principle contemplate the establishment of alternative water management systems. For instance paragraph 28.1.3 of the Dene/Metis agreement calls for the establishment of a "Land and Water Board" within two years of settlement legislation. Like arrangements are expected to be made for the Inuvialuit area.

Once this happens, the N.W.T. Water Board will cease to exist, but presumably licences issued by it will remain in good standing until their expiry or until replaced by licences issued by the new Boards.

Currently technical and administrative services are provided to the Board by D.I.A.N.D. who also are in charge of inspection and enforcement. The agreements in principle are somewhat nebulous as to how these functions will be fulfilled in future.

Clarifying what might be considered common law riparian rights the agreements also provide for compensation for the claimants when the quantity or quality of water flowing through or adjacent to their lands is significantly altered. This would only likely become cause for concern in the largest municipalities.

Municipal Licensing Compared to Industrial Licensing

The Water Board is oftentimes accused of operating on a double standard - one for industrial licences which are rigorously enforced and another for municipalities where conditions tend to be more relaxed. This is a reflection of the facts that the Board could hardly refuse to issue a licence to a municipality or revoke one once issued. It would be difficult to put the mayor in jail or even fine the community for infractions of their licence and the Board knows that most municipalities in the N.W.T. are dependent almost entirely on senior levels of government for financing water and sewage improvements.

The Board certainly appreciates the work being done by MACA under difficult circumstances and with limited resources to upgrade water and sewage facilities throughout the territories.

With reference to the appendix it will be seen there are still quite a number of communities which still do not hold a licence although they are required to have one under the Northern Inland Waters Act which has been law since 1972. The Board would like to sign these up and agrees with MACA that often the best time to do so is when a major upgrade to the system is taking place.

Although licences are issued to the municipalities sometimes problems arise when the Territorial Government is the owner and operator or the water/sewer system but the Board is aware that the policy being pursued is to transfer these responsibilities to the municipalities so hopefully such problems will eventually work themselves out. Some licensees such as Fort Good Hope which strictly speaking is not lawfully incorporated are of doubtful legal status, but this problem will presumably be rectified in the near future when such communities become incorporated under the Settlements Act or the Charter Communities Act.

Inspection reports received by the Board indicate that while some communities are doing a good job, a number still need to upgrade their standards of cleanliness and good housekeeping where water supply and sewage disposal are concerned. In the interests of public health this Board urges MACA to continue with its campaign of education in this field.

For some time the Board has adopted a policy of disallowing the discharge of untreated sewage into principle water courses. With some notable exceptions such as Fort Simpson, where the Board had a major concern over the proposal to chlorinate the effluent and still has concerns about the timing of phase 2, this is often accomplished using lagoons. As the population increases and public concern over environmental and health matters comes more and more to the forefront it is debatable how long lagoons, which have limited performance characteristics in cold climates, will be seen as a preferred option. Research into alternatives or improving performance might well be in order and MACA should brace itself for major undertakings such as that which might be required for the City of Yellowknife.

APPENDIX

SEP 1 1 90

AD 0019
GT 0021

LICENSED COMMUNITIES

90-09-06

<u>Licence #Number</u>	<u>Name</u>	<u>Licence Terms</u>
N1L4-0032	City of Yellowknife	July 6/89 - Oct. 30/92
N3L4-0036	Town of Inuvik	July 1/83 - June 30/93
N1L4-0041(1)	Hamlet of Rae Edzo (Rae)	Oct. 1/83 - Sep. 30/93
N1L4-0041(2)	Hamlet of Rae Edzo (Edzo)	Oct. 1/83 - Sep. 30/93
N1L4-0053	Town of Hay River	June 15/81 - June 14/91
N5L4-0087	Iqaluit (presently being renewed)	June 1/79 - June 1/84
N3L4-0095	Hamlet of Norman Wells	Sep. 1/83 - Jan. 31/87
N5L4-0159	Nanisivik	Dec. 31/86 - Oct. 31/91
N1L4-0165	Pine Point	Oct. 1/81 - Sep. 30/91
N3L4-0463	Village of Fort Simpson (presently being reviewed)	Jan. 1/85 - Dec. 31/90
N2L4-0555	Hamlet of Fort Franklin (presently being reviewed)	Aug. 1/80 - July 31/90
N1L4-0567	Town of Fort Smith	Jan. 1/90 - Dec. 31/90
N3L4-0570	Hamlet of Aklavik	Apr. 1/89 - March 31/99
N4L4-0640	Hamlet of Broughton Island	Oct. 1/89 - Dec. 31/95
N7L4-0714	Hamlet of Tuktoyaktuk	March 1/84 - Feb. 28/94
N6L4-0779	Hamlet of Rankin Inlet	Sep. 1/83 - Aug. 31/93
N3L4-1112	Settlement of Fort Norman	May 1/85 - April 30/95
N6L4-1191	Hamlet of Baker Lake	Sep. 1/83 - Aug. 31/93
N1L4-1395	Settlement of Snowdrift	May 1/85 - April 30/91
N1L4-1412	Settlement of Fort Providence	May 1/85 - April 30/2000
N5L4-1441	Hamlet of Lake Harbour (presently being reviewed)	Oct. 1/85 - Dec. 31/90

N5L4-1447	Hamlet of Pangnirtung (presently being reviewed)	Oct. 1/85 - Dec. 31/90
N1L4-1477	Hamlet of Lac La Martre	Jan. 1/87 - Dec. 31/96
N3L4-1478	Settlement of Fort Liard	Jan. 1/87 - Dec. 31/96
N7L4-1525	Hamlet of Holman	July 1/88 - June 30/98
N7L4-1526	Hamlet of Coppermine	July 1/88 - June 30/2003
N4L4-1532	Hamlet of Cambridge Bay	July 1/88 - June 30/95
N7L4-1557	Settlement of Arctic Red River	May 1/89 - April 30/99
N4L4-1561	Transport Canada Resolute Bay	May 1/90 - April 30/96
N4L4-1571	Hamlet of Resolute Bay	May 1/90 - April 30/96

UNLICENSED COMMUNITIES

Arctic Bay
Cape Dorset
Clyde River
Colville Lake
Detah - being licensed
Enterprise
Arviat
Fort Good Hope - being licensed
Fort MacPherson
Fort Resolution
Gjoa Haven
Grise Fiord
Hall Beach
Jean-Marie River
Settlement of Kakisa
Nahanni Butte
Paulatuk
~~Paulatuk~~
Settlement of Rae Lakes
Repulse Bay
Salt River
Sanikiluaq
~~Sanikiluaq~~
Trout Lake
Whale Cove
Wrigley

Above Treeline Snowdrift Prevention Measures

Malcolm MacPhail,

Yellowknife, NWT.

3rd ANNUAL TECHNICAL CONFERENCE

of the

Department of Municipal and Community Affairs

Municipal Planning Engineers

ABOVE TREELINE
SNOWDRIFT PREVENTION MEASURES

As population and infrastructures of communities grow there is an increasing demand for municipal services. Communities have expanded and more services are being offered. At the same time it has become more difficult at certain times of the year to deliver these services because of snowdrifting problems. Communities in the past have been laid out without taking long range snowdrifting patterns into consideration. As a result governments are investigating ways to solve this problem, or at least provide for some snowdrifting relief.

A beginning to snowdrift prevention and management is to conclude where in the community the problem exists. For the majority of NWT communities with snowdrifting complaints, their problem is mainly the accumulation of snow on roadways and around buildings. In most of the communities where they experience bad snowdrifting, access to the roadway, and access to (driveways) the service points once they get there are part and parcel of the same problem.

Another complication, although rarely mentioned, is visibility. Inasmuch as roads may be relatively free of snow, travel is restricted because operators cannot see where they are going. This situation has potential hazards, and should not be overlooked. These roads are usually ones that extend outside of the community going to garbage dumps and sewage lagoons.

Community maintainers have to decide the extent of their snow problems insofar as determining is it access to the property off the road, mobility on the road itself or a combination of both? This usually varies to different degrees in separate areas of the community. Maintainers will have to determine what is causing their snowdrifting. This is not as easy a task as one may assume. Unless community managers have experience or training in microclimate assessments, it is quite understandable they may not recognize what is a probable cause of their snowdrifting.

Snowdrifting patterns should be recorded on a community plan which would include measurements and dates. Photographs in addition to the marked community plan will help determine problem areas and possible solutions. A community plan will also show some of the topographical features that could be contributing factors. Any historical data that may be around should be gathered and analyzed with present day conditions.

Maintainers will want to gather meteorological data to determine prevailing wind direction(s), periods of blowing snow, snowfall accumulation, and number of days below freezing. In most places, this data will be available at the local weather station.

The information is essential to begin putting in place some snowdrifting solutions.

Improper snow ploughing techniques and unsuitable snow storage areas may be other contributing causes to snowdrifting and should not be ignored. It is possible maintainers will have to seek advice in this area as they may with other questions.

Once maintainers have determined where their actual problem lies, obtained weather data, gathered and marked possible causes of snowdrifting, they will be able to start looking at possible solutions.

SNOW CLEARING

Recognized snow clearing techniques are a must to efficiently and effectively carry out snow clearing activities on major roads and community streets. One way of doing this is to have a management system that includes approved quality standards, level of service and work methods¹ for which their works crew and/or contract forces can use as guidelines.

Prior to the community's snow season, Works Foreman would inspect the community road network to ensure there are man made obstructions or debris on their roads, in ditches and on open spaces (hinterland) that will encourage snowdrifting. Such things as left over construction materials, large boulders etc. should be removed. This inspection and subsequent cleanup of sites can contribute significantly to reducing snow ploughing and/or snow removal expenditures.

It is being recognized some communities may have to implement by-laws to provide for the approval and site inspection of new structures on already developed property. Also, legislation that will provide for the cleaning up or organization of sites that contain material that contributes to snowdrifting.

SNOW PLOUGHING ROADS

To prevent excessive exposure and loss of gravel a snow cushion of 1 to 2 cm must be left on the road surface. Although it is desirable to leave a small amount of snow to protect gravel surfaces, particular attention must be given to all intersections, bridges, hills and corners. Operators should remove as much snow as possible at these locations.

¹ for example; Task Description Section 15. Roads, Community Works Management System (CWMS)

Snow ploughing with either motor grader or truck mounted plough should start with the intention of ploughing all snow downwind off roads. For major traffic roads such as an airport or garbage dump road, ploughing snow off the road usually presents little problem as the road is normally along open (hinterland) areas with plenty of room for snow storage and feathering. All windrowed snow along the side of the road should be feathered or trimmed whenever possible, and as soon as possible to prevent windrowed snow to act as mini snow berms. Snow banks that are feathered have less of a chance of trapping more blowing snow. In areas where there is limited room to feather snow banks, designated snow storage areas should be determined, and be as close a possible to these areas. An example may be vacant building lots or fields where no building construction is done. Snow should not be stored or piled near corners or intersections where visibility will be restricted. Low areas in the community are often good areas for snow storage. For sites with limited snow storage space, this snow should be removed and hauled away to lessen future drifting. Areas that have been picked for snow storage will also require adequate spring drainage avenues.

SCHEDULING

Equipment scheduling is an important aspect of controlling snow removal/ploughing expenditures. It is not efficient to have for example your truck service vehicles out before the roads they travel on clear of snow. It is not efficient for a crawler tractor to be out clearing long distances if there is a motor grader or plough truck available. The Works Foreman should always be prepared with a work plan and an alternate plan to see that the right equipment is out at the right time, and doing the job best suited to their capabilities.

A review of mobile equipment snow ploughing attachments should be done to better utilize snow ploughing vehicles. Snow blades for crawler tractors and one-way ploughs for dump trucks are ways of the increasing efficiency of vehicles.

TRAINING

It is recommended that works employees, supervisory staff, contract forces and all other persons involved with snow management activates be given introductory instruction and training in all aspects of the community's snow management program. This would be an annual training event with an appropriate budget set aside for this exercise. Ongoing monitoring of instructions by supervisory staff is required to maintain continuity. Prior to the snow season works crews and/or contract forces, usually the heavy duty equipment operators would be given a review of snow ploughing and

removal techniques in accordance with Hamlet policy to refresh their memories and to instruct new operators. If the community does not have a snow management program, one should be developed.

It is important for supervisory personnel to monitor weather information and review historical data to assist in planning snow ploughing/removal activities. This data can be used to estimate snow removal costs and crew scheduling.

SNOWBERMS

Snowberms have been constructed in Baker Lake since the winter of 1987. Snowberms were constructed to collect snow upwind of selected parts of the community. Berms were constructed to protect roads, and some berms were constructed to protect access to trucked service points (driveways).

These snowberms have been largely effective in that large volumes of snow have been trapped. Snow berms in Baker lake were constructed in two different ways. Berms were shaped in a specific area from drifting snow at that site. The snow was pushed up into long, and as high as possible berms immediately following each blizzard. Each storm collected more snow which was again pushed into the snow pile, and as high as was safely permitted by crawler tractors. Other snowberms were constructed with trucked snow from other areas of the community. Sort of like putting drifting snow back to work for us. At some point the size of a berm reached a height which the crawlers could not push snow any higher. When the snowberms reached this stage, the berms were then "benched". The top part of the snow slope was cut to leave a platform that was able to collect more drifting snow. The berm would begin to take the shape similar to that of haul roads in an open pit mine. Excess snow from the cut was generally pushed off the ends of the snowberm increasing the overall length.

Multiple snowberms were also tried and found to be quite effective. This was only possible where there was an adequate amount of space, but were found to be able to collect much larger volumes of snow.

Snowberms act in much the same way as a solid snowfence. Snowberms are costly in respect to equipment and manpower requirements. Prompt maintenance (reshaping) of snowberms following each storm is required if they are expected to continue providing snowdrifting relief. Timely and effective direction of manpower and equipment is needed. As with snowfences, snowberms require a lot of storage space or they are able to bury nearby buildings and roads.

PROPERTIES OF SNOW

To understand how snowfences work, one must understand how and why snow is transported by the wind. Snow particles or crystals are very small, approximately 3 millimetres across as they fall through the air. If the crystal makes it to the ground without being crushed, it will strengthen as its tips evaporate and the voids are filled with condensation. A fairly large snow particle results from this process. Snow particles on the ground will bond together over time. In other words, the longer the snow stays on the ground the less likely it is to be transported by the wind.

If the bonds holding the snow particles together are overcome by the wind, the particles will start to roll, jump along the surface or become airborne depending on the grain size. The largest particles will roll, or creep, along the surface pushed by the wind. As one particle lands, it will hit another particle, causing that particle to jump. The smallest particles will be suspended in the air and carried by the wind. The particle size of the three transportation modes is not fixed; it depends on wind speed, temperature and humidity.

SNOWFENCE CHARACTERISTICS

To design an effective snowfence for a particular location, the snowfall, its moisture content, the amount of snow that will stay on the ground due to melting, bonding, or vegetation/terrain-wind cover, the duration and intensity of the wind, and the area upwind of the snowfence, from where the snow would be transported, must be known. If the area upwind of the fence (the fetch) is large, one would believe that the amount of transported snow would be enormous. However, as it is transported, the snow grains abate. The rate of abatement depends on relative humidity, solar radiation and snow particle size. Ten thousand (10,000) feet is commonly used as an average maximum fetch distance for calculating snow transport rates, because most snow particles have abated beyond this point.

A collector snowfence can be constructed of many different materials and in various configurations. Because porous snowfences work best, most designs consist of vertical or horizontal slats or boards with openings between them.

During the 1980's fabric snowfences have been developed. Typically, these consist of plastic fabric with 40% - 60% porosity which is stretched between vertical posts. Solid snowfences are also able to collect blowing snow, but only one-third the collecting capacity of porous fences with a bottom gap. Solid snowfences are mostly used for wind protection.

Why do snowfences collect snow? A common belief is that fences slow the wind, and the wind carried snow settles to the ground. This explanation is not quite correct. The snow will be eroded where the wind induced shear stress is higher than the shear strength of the snow on the ground. Wind transported snow will be deposited where the wind induced shear stress is too low for transport. A properly designed snowfence takes advantage of this by creating a wind profile behind the fence favourable to snow disposition.

The ability of a collector snowfence to catch wind transported snow is called its trapping efficiency. Absolute trapping efficiency refers to the fence's ability to catch snow from the ground up; while trapping efficiency refers to the ability to trap wind driven snow between the ground and the top of the fence. The trapping efficiency of a well designed snow fence will start out at about 95% for an empty fence, and slowly declines as the fence fills with snow. When the fence is about 80% full, the trapping efficiency will rapidly decline to zero.

When the trapping efficiency reached zero, no more snow is caught by the fence, and the fence is considered mature. To catch most of the wind driven snow during a season, the fence should be designed so that it does not mature and will thus retain a high trapping efficiency.

The capacity of a collector snowfence is directly related to its height. For areas that experience large volumes of drifting snow, it is recommended the higher the better. A properly designed snow fence will also include an open bottom gap. The gap should be in the order of 10% - 15% of the overall height of the fence. The height and integrity of the fence is very important. The primary purpose of the bottom gap is to prevent the fence from being buried. The bottom gap forces the wind driven snow to speed up under the fence preventing deposition, and in the case of snowfall accumulation under the fence, erosion.

The snowdrift behind the snowfence, forms in a predictable manner. The drift will first be fairly high and short, Later it will start to streamline and lengthen. When the fence matures, the drift will be very long and aerodynamic. The mature drift will be up to 15% higher than the fence itself.

SNOWFENCE PLACEMENT

After the type and height of the collector fence snowfence has been selected, the length and location of the fence must be determined. Naturally, the fence should be placed upwind of the area to be protected. The prevailing wind direction or directions during the snowy season must be gathered from local weather data.

The fence should be placed perpendicular to the prevailing wind, and be as long as practical. One long fence is better than several shorter ones as the sides of the drifts are rounded, and rounding reduces the capacity of the fence.

The snowfence should be placed at least one leeward drift length away from the area to be protected. The probable locations of drifts must be predicted before installing the snow fence so that drifts do not form in an unsuitable location. All the different prevailing wind directions must be considered in this analysis. Snowfences require a lot of area. For instance, a 15 foot high by 1000 foot long fence in an area with two opposite prevailing wind directions needs an area 1020 feet by 1000 feet, or almost 24 acres.

The topography of the area around the snowfence could have a detrimental or positive impact of the performance of a particular snowfence. If a fence is placed at the beginning of a down slope, the capacity of the fence will increase; if the fence is placed at the beginning of an uphill slope, the capacity will decrease.

A demonstration snowfence was constructed in Baker Lake for the snow season 1989/90. The fence was placed on hinterland on the northwest edge of the community to provide snowdrift relief to a specific area in town. This area was chosen for its congested residential housing and for its own limited snow storage capacity. As this was a first in snowfence construction in Baker Lake, this effort was also experimental in nature. The fence was placed in an area that provided for adequate snow storage, although more space would have been desirable. We were limited in space due to other uses of the land.

For the purpose of the demonstration snowfence, durable plastic Tensar fence was chosen. The Tensar was advertised as 50% porous and came in four foot widths and one hundred foot rolls. Steel pilings were used as uprights and sunk four feet into the ground. The pilings were placed at forty foot intervals over a total distance of three hundred and sixty feet. It would have been desirable to double the amount of uprights but financial considerations prescribed the amount in this demonstration. Four widths of Tensar was used to bring the height of the snowfence to eighteen feet, with a bottom gap of approximately twenty inches. Polyethylene rope was used to tie the sections of the Tensar together and secure it to the posts. Heavier poly rope was used to provide additional stability of the fence in the shape of an X between pilings. No guy wires were used.

The prevailing wind in Baker Lake is generally from the north-west, (78% of the time²). The snowfence was orientated perpendicular to the prevailing wind for maximum benefit. The hinterland was relatively flat and was therefore not expected to provide any surprises in itself. Immediately upwind and to the west of the snowfence the community had been constructing snowberms to provide snowdrift protection to a group of houses and was not a part of this demonstration.

To determine the snowfence's ability to collect snow, measurements of the transport rate were taken both upwind of the fence and downwind of the fence. These measurements were taken during February 1990 when winds speeds at the airport averaged 46 km/h, gusting to 62 km/h and blowing from 320 degrees. The top of a pan was embedded flush with the snow's surface and the time it took the wind to fill the pan with snow was recorded. When the pan was located 30 feet upwind of the fence to measure the transport rate of snow approaching the fence, it filled within 1.8 minutes. The same pan placed approximately 300 feet downwind of the fence filled in 18.5 minutes. This is approximately a 10:1 difference in time indicating in simple terms, that for every 10 snow particles approaching the snowfence, 9 of them were collected by the fence with 1 escaping into the community³. This clearly indicated that the demonstration snowfence provided snowdrift protection to the area downwind of the fence as was the intention.

The area downwind of the snowfence was kept largely clear of snow throughout the effective period of the snowfence. Once the fence became mature, the area quickly became filled with drifted snow. This fence received very little attention in regards to preventative maintenance, and as winter progressed the poly rope became undone, and sections of the Tensar began to pull apart. Near the end of the snowfence's usefulness, Baker Lake received extreme cold temperatures accompanied by wind winds. The Tensar coupled with severe windchill and high winds eventually caused the plastic to tear and looked quite bedraggled. The apparent failures in the Tensar plastic in the writers opinion was in no way due to the materials itself, but rather the fact no preventative maintenance was carried out.

Snowfences are a marvellous method for snow abatement, but they are not to be viewed as a catch all solution to snowdrifting problems. Communities should look seriously at what their problem really is before undertaking snowfencing in the hopes that is the

² RWDI report 48712212 Sept 1987 for MACA)

³ Bill Waechter of Rowan Williams Davies & Irwin (RWDI) compiled this information and was submitted in report 90-210T-021, April, 1990.

end of their snow difficulties. In many instances, a better understanding of what causes snowdrifting and proper training in dealing with drifting snow can solve many dilemmas. Education and training for designers and planners, building occupants, works maintainers, supervisory staff and Councils can go a long ways to reducing these concerns.

Malcolm MacPhail, for
Municipal & Community Affairs

BATCH FLUORIDATION OF WATER STORAGE RESERVOIRS

- A MODIFIED PROCESS -

by: Cam Marianayagam, P.Eng.¹
Ron Kent, P.Eng.²
Ken Johnson, P.Eng.³

INTRODUCTION

Dental caries (tooth decay) is widespread in the Northwest Territories (NWT), and its incidence is especially high among native people. It is a multi-factorial disease that is best countered by a combination of good nutrition, improved oral hygiene and the use of fluoridation practices. Fluoridation of water supplies to about 1.2 mg/L is considered to be an effective fluoridation practice, because fluoride strengthens the enamel during tooth formation.

In 1986, the Government of the Northwest Territories (GNWT) initiated a health-oriented performance and engineering study on the feasibility of fluoridating community water supplies.

The study resulted in the development of the batch fluoridation process as a safe and effective means of water fluoridation in communities that process year-round water storage reservoirs (Marianayagam, 1986). In the batch fluoridation process, fluoride is injected into the reservoir fill line during the annual reservoir filling operation. The addition of fluoride during the filling of the reservoir was recommended for the following reasons:

- a) Thorough mixing of the fluoride chemical with the water would take place due to the turbulence in the supply line between the point of injection and the storage reservoir.
- b) Fluoridation of the reservoir would be done once a year and therefore require skilled supervision for a period of time during the reservoir filling process.

A field trial was conducted in 1987 utilizing the reservoir in Tuktoyaktuk, to demonstrate the technology of batch fluoridation (Murray, 1987). The reservoir was successfully fluoridated and has been fluoridated on an annual basis since the field trial.

The process in Tuktoyaktuk involves the injection of the fluoride chemical into the fill line at a concentration that does not exceed 1.5 mg/L; the maximum acceptable concentration in potable water according to the Guidelines for Canadian Drinking Water Quality. At this concentration, the addition of the fluoride chemical could take approximately 10 to 15 days.

In the Tuktoyaktuk reservoir, the outlet of the fill line is immediately adjacent to the truckfill intake, with both pipes entering the reservoir from the bottom. The close proximity would result in short-circuiting of the fluoride chemical between the two pipe openings. Unless the fluoride is injected at a concentration that does not exceed 1.5 mg/L, short-circuiting would result in unacceptable concentrations of fluoride entering the trucked water distribution system.

[For additional background information on dental health in the NWT and the batch fluoridation program in Tuktoyaktuk, the reader is encouraged to review Marianayagam et al (1988), Murray and Heinke (1988(1)), Murray and Heinke (1988(2)) and Johnson and Murray (1990)].

In 1989, the GNWT expanded the batch fluoridation program to include reservoirs in two eastern Arctic communities, viz. Pangnirtung and Igloolik. The fluoridation of these reservoirs was carried out using a major modification of the established process for the Tuktoyaktuk reservoir.

THE MODIFIED PROCESS

The reservoirs in Pangnirtung and Igloolik were fluoridated by injecting the fluoride chemical into the reservoir fill line at concentrations greater than 20 mg/L. The chemical was injected at this rate on a trial basis, in order to try and minimize the amount of time, and subsequent cost, of skilled supervision during the reservoir filling period. The piping configuration in both reservoirs favoured this approach, because unlike the Tuktoyaktuk reservoir, the distances between the fill line outlet and truckfill intake are relatively large, particularly in the Pangnirtung reservoir.

The fluoridation systems utilized in Pangnirtung and Igloolik are illustrated in Figures 1 and 2 respectively.

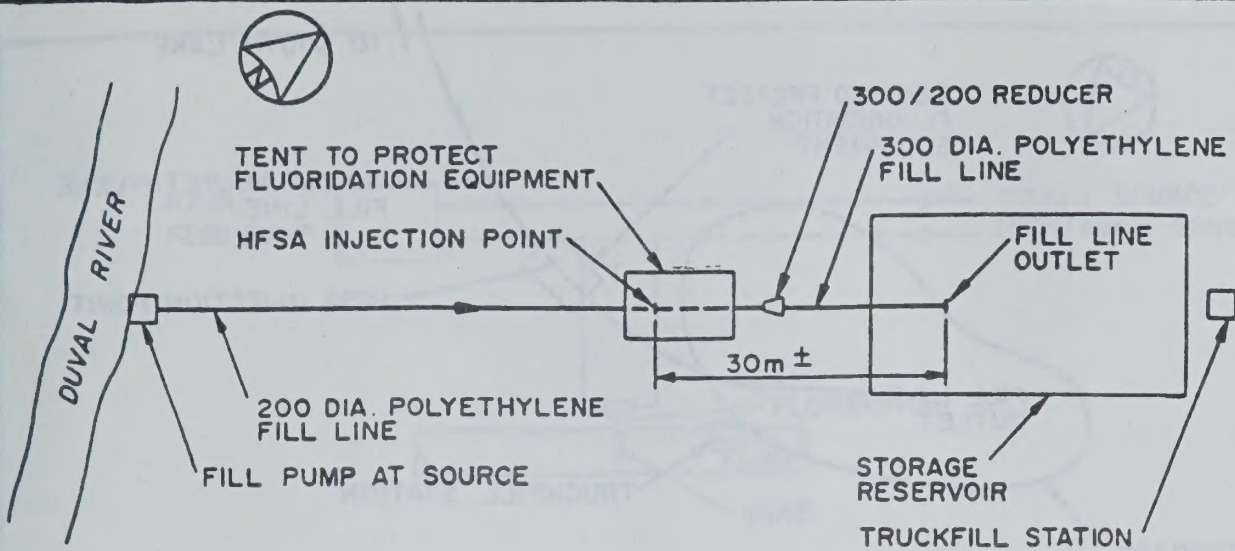
PRECAUTIONS

Several precautions were taken to ensure that the modified process remained a safe and effective means of adding the fluoride chemical to year-round storage reservoirs. These are outlined below:

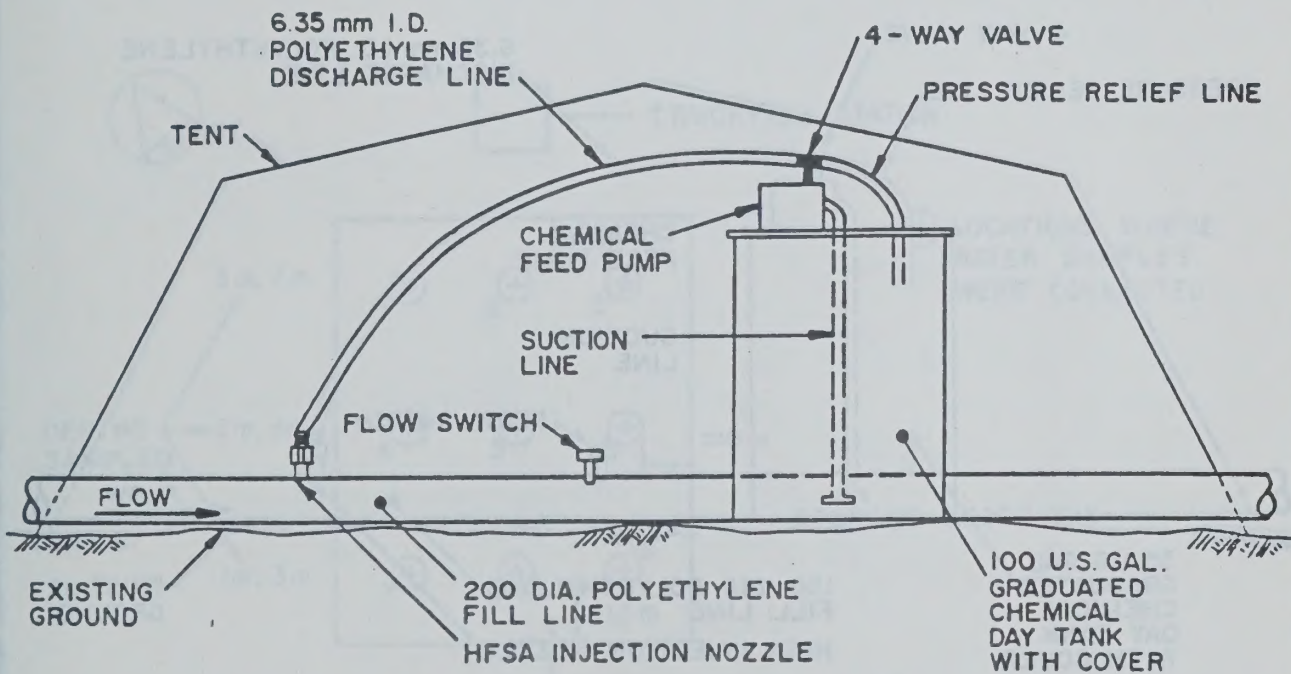
- i) Water samples were collected from the reservoir and analyzed for fluoride concentrations at least once each day. The location of water sampling points was established by an approximate grid across the reservoir. Figures 3 and 4 indicate the approximate water sampling locations for Pangnirtung and Igloolik respectively.

Water samples were collected at various depths at these locations to monitor the dispersion of the fluoride chemical plume through the reservoir. The results of these samples are presented in Table 1 for Pangnirtung and Table 2 for Igloolik. The results indicated there was a relatively uniform dispersion of the chemical plume between the outlet of the reservoir fill line and truckfill intake. There was no evidence of short-circuiting of the fluoride chemical between these two locations, which would have resulted in the withdrawal of water with excessive concentrations of fluoride.

The monitoring programs were continued until the desired initial fluoride concentrations in the reservoirs were achieved.

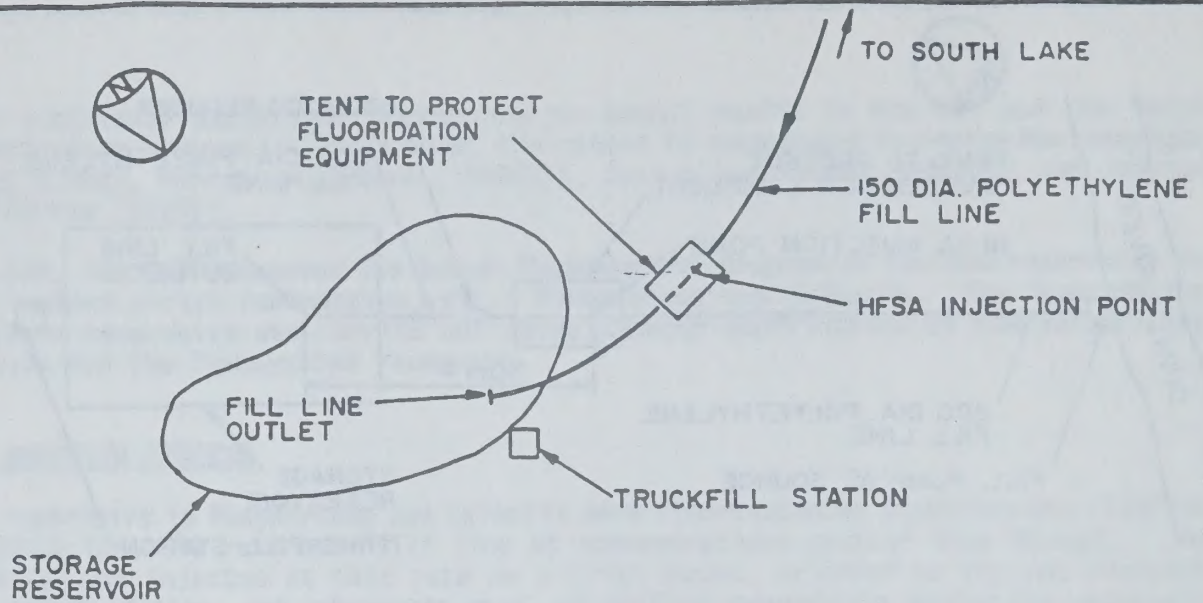


a.) SCHEMATIC LAYOUT
N.T.S.

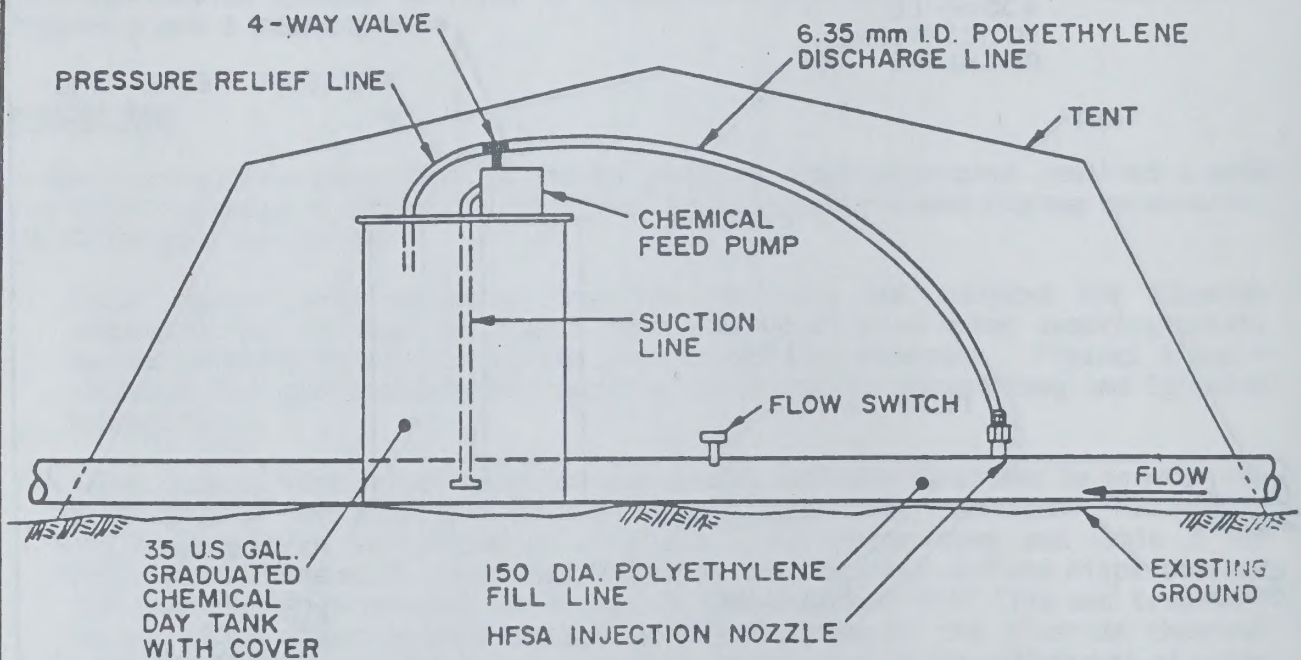


b.) HFSA FEED SYSTEM INSIDE TENT
N.T.S.

PANGNIRTUNG
FLUORIDATION SYSTEM



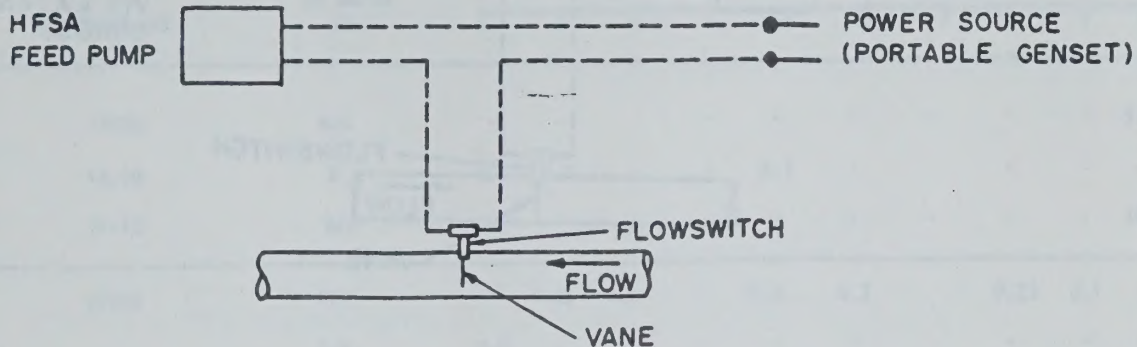
a.) SCHEMATIC LAYOUT
N.T.S.



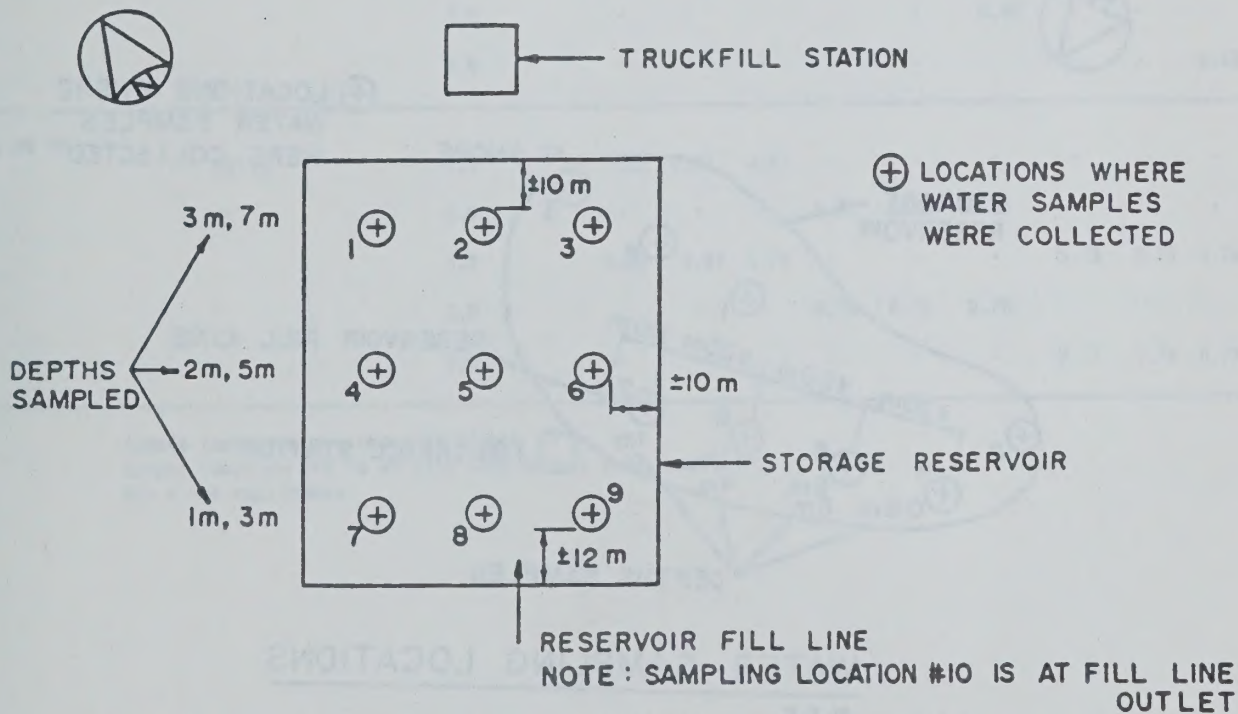
b.) HFSA FEED SYSTEM INSIDE TENT
N.T.S.

IGLOOLIK FLUORIDATION SYSTEM

FIGURE 2

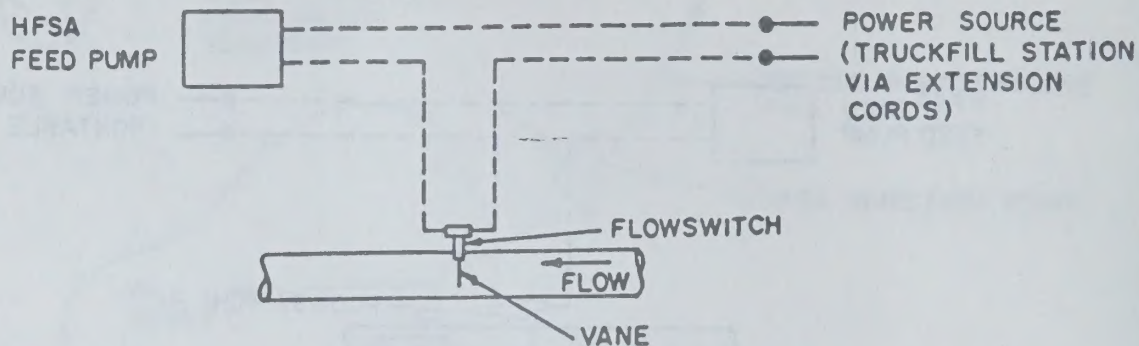


ELECTRICAL CONNECTION - SCHEMATIC
N.T.S.

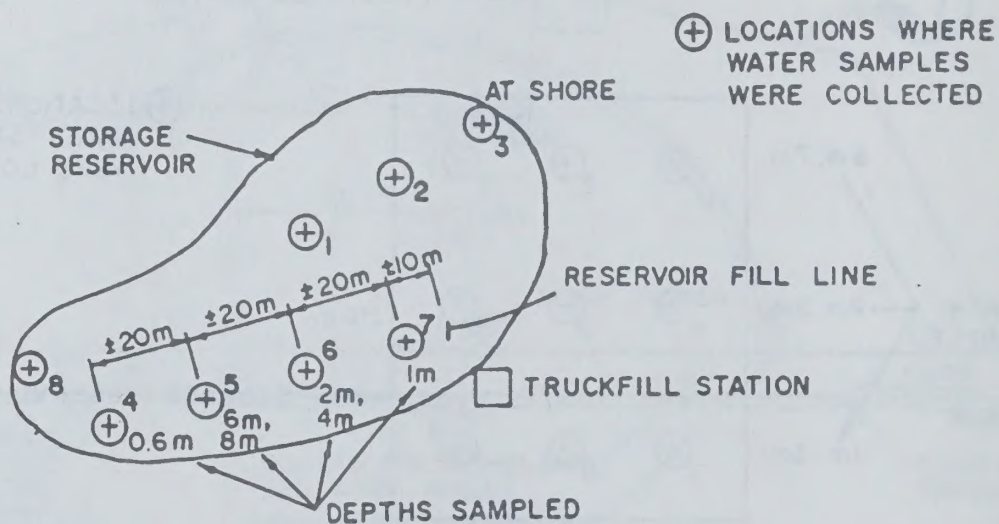


WATER SAMPLING LOCATIONS
N.T.S.

PANGNIRTUNG



ELECTRICAL CONNECTION - SCHEMATIC
N.T.S.



WATER SAMPLING LOCATIONS
N.T.S.

IGLOOLIK

TABLE 1

FLUORIDE MONITORING DURING 1989
ADDITION OF FLUORIDE - PANGHIRTUNG RESERVOIR
FLUORIDE CONCENTRATION AT VARIOUS LOCATIONS, DEPTHS AND TIMES

DATE DAY/MON/YR	TIME OF SAMPLING	SAMPLE TAKEN AT DEPTH (m)	LOCATION NUMBER									
			1	2	3	4	5	6	7	8	9	10
02 09 89	15:30	N/A	-	-	-	-	-	-	-	-	-	8.88
	16:00	0	0.1	0.1	-	-	0.1	-	-	-	-	-
	19:12	N/A	-	-	-	-	-	-	-	-	-	16.0
03 09 89	09:00	0.0	-	0.25	0.2	-	0.3	0.3	-	0.25	0.1	-
		1.0	0.2	-	-	-	-	-	-	-	-	-
		2.0	-	-	-	0.3	-	-	-	-	-	-
		4.0	-	-	-	-	-	-	0.3	-	-	-
04 09 89	09:15	0.0	0.62	0.61	-	0.50	0.45	-	0.42	0.40	-	-
		1.0	-	-	0.58	-	-	-	-	-	-	-
		3.0	-	-	-	-	-	0.45	-	-	-	-
		5.0	-	-	-	-	-	-	-	-	0.42	-
06 09 89	09:15	1.0	0.83	0.81	0.81	-	-	-	-	-	-	-
		2.0	-	-	-	0.72	0.73	0.75	-	-	-	-
		3.0	0.82	0.81	0.79	-	-	-	0.78	0.75	0.76	-
		5.0	-	-	-	0.75	0.72	0.78	-	-	-	-
		7.0	-	-	-	-	-	-	0.79	0.76	0.75	-

NOTE: - Sample locations are shown in Figure 3
- Sample location #10 is at fill line outlet into reservoir.
- N/A = not applicable

TABLE 2

FLUORIDE MONITORING DURING 1989
ADDITION OF FLUORIDE - IGLOOLIK RESERVOIR
FLUORIDE CONCENTRATION AT VARIOUS LOCATIONS, DEPTHS AND TIMES

DATE DAY/MON/YR	TIME OF SAMPLING	SAMPLE TAKEN AT DEPTH (m)	LOCATION NUMBER							
			1	2	3	4	5	6	7	8
10 09 89	15:00	0	0.5	0.5	-	-	-	-	-	-
		1	-	-	-	-	-	-	0.60	-
		4	-	-	-	-	-	0.54	-	-
		8	-	-	-	-	0.60	-	-	-
11 09 89	11:20	0	-	0.70	0.60	0.59	-	-	-	0.80
		1	-	-	-	-	-	-	0.60	-
		4	-	-	-	-	-	0.59	-	-
		8	-	-	-	-	0.60	-	-	-
11 09 89	20:20	0	-	0.71	-	0.71	-	-	-	0.71
13 09 89	09:45	0.0	-	-	0.92	-	-	-	-	0.85
		0.3	0.85	0.85	-	-	-	-	-	-
		0.6	-	-	-	0.80	-	-	-	-
		1.0	-	-	-	-	-	-	0.80	-
		2.0	-	-	-	-	-	0.81	-	-
		6.0	-	-	-	-	0.78	-	-	-

Note: Sample locations are shown in Figure 4

- ii) In addition to the sampling/testing program, samples were occasionally taken from the truckfill arm during the filling of water trucks to check whether the fluoride concentrations were approximately equal to the fluoride concentrations measured in samples collected from sampling points in the reservoir, close to the truckfill intake. In all such tests, the differences were insignificant.

CONCLUSIONS

The modified process was a success. It not only achieved the required end results, but enabled a significant reduction in duration, and subsequent cost, of skilled supervision of the fluoridation process during the reservoir filling period. The amount of time spent in each community was reduced to about 4 to 5 days.

The modified process can be a safe and effective means of adding the fluoride chemical to year-round storage reservoirs, as long as the necessary precautionary measures are observed. Further, it is evident that the process will probably succeed in the Tuktoyaktuk reservoir too, if arrangements can be made to suspend the trucked delivery system for the duration of fluoridation. In this way, there can be no short-circuiting of fluoride chemical in the reservoir.

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THE CAPITAL PLANNING AND RESOURCE ALLOCATION PROCESS
DEPARTMENT OF MUNICIPAL AND COMMUNITY AFFAIRS

MUNICIPAL AND COMMUNITY
AFFAIRS
CAPITAL PLANNING PROCESS
&
SCHEDULE
1992/93 - 1996/97

THE CAPITAL PLANNING AND RESOURCE ALLOCATION PROCESS
DEPARTMENT OF MUNICIPAL AND COMMUNITY AFFAIRS

=====

Following is a description of the process to be followed by the Department in preparing the 1992/93 Capital Estimates and Five Year Forecast. The objective of this process is to result in a capital budget that is both technically sound and politically responsive to the community and Ministerial levels of Government.

To assist in focusing the required attention and effort on those objectives in the most efficient and effective manner; the process has been divided into an iterative series of Capital Planning and Resource Allocation phases.

The Capital Planning Phases address the technical requirements of the capital budgeting process.

The Resource Allocation Phases provide the opportunity for the Minister to respond politically to community needs. It is during the Resource Allocation Phases that the Minister will determine the most effective allocation of the Departments anticipated Capital Budget for the next fiscal year and the tentative prioritization of the remaining project needs over the ensuing years of the Five Year Capital Forecast period.

The Capital Planning and Resource Allocation Process consists of six distinct Phases. They are as follows:

PHASE I - Capital Planning - Community Level

1. Phase 1 consists of:

- i) the assessment of community specific project needs (deficiencies) with respect to the Standards and Criteria established for eligible projects under each of the Department's Capital programs;

NOTE: The final capital plan of the Department is to represent a total needs statement, by project, as defined by the Standards and Criteria for each of the Department's Capital Programs.

- ii) assessment of the Capital and O&M implications of incorporating the Department's "Developmental" requirements into the project design and project implementation schedule (in consultation with DPW);
- iii) determination of the most economical and desirable implementation schedule for capital planning purposes (in consultation with DPW);
- iv) evaluation and determination of the overall O&M cost implications to the community and to the NWT Government;
- v) identification of project impacts on other NWT Government Capital Programs (eg. Department of Personnel Staff Housing Program);

- vi) preparation of capital cost estimates in consultation with DPW for each project on a fiscal year by fiscal year basis;
 - vii) consultation with other Capital Program Departments of the NWT Government (eg. Education, Social Services, etc.) to ensure all departmental capital plans within each region are coordinated; and,
 - viii) notification and involvement of the local MLA in the development of each individual community's Five Year Capital Plan.
 - ix) preparation of individual community Five Year Capital Plans - by Program.
2. The 1991/92 capital allocation, and associated historical trends should be used by Headquarters and Regions, as a guide to indicate a realistic expectation of the capital amounts that will ultimately be available to each Region and Headquarters for the 1992/93 fiscal year.
3. In preparation of the Department's capital plan, those projects that cannot be physically or practically implemented during the present five year capital planning cycle should be shown as projects to be implemented in "future years".

Examples of such constraints would be:

- i) if certain other projects must be implemented before the project in question may commence;
- ii) if so many projects are required for a particular community that a "boom and bust" impact on the local economy may be created if they were all to be implemented over the 5 year time frame;
- iii) if additional time is required to maximize opportunities for local involvement and community development during the implementation of certain capital projects; or,
- iv) if the Department of Municipal and Community Affairs, the Department of Public Works or Community Council management resources are unlikely to be sufficient to manage the project(s) proposed.

N.B. The potential lack of financial resources alone is not a reason for deferring a project to "Future years" in the Capital Planning Process.

Projects which are not required until later years (i.e. beyond the Five Year Capital Forecasting Plan) should be identified in the 20 year capital needs forecast to be implemented in the year(s) they are forecast to be needed.

- 3 -

4. Each Regional Superintendent is responsible for the management and implementation of the Phase I - Capital Planning process for non-tax based communities (i.e. all organized communities, except Villages, Towns and Cities). Division Directors are responsible for the Phase 1 - Capital Planning process as it applies to project needs in tax-based communities (i.e. Villages, Towns and Cities).
5. Each Regional Superintendent and Division Director is also responsible to foster an awareness at the community level that the Capital Budgeting Cycle consists of two distinct activities - one being Capital Planning and the other being Resource Allocation. In the Phase I - Capital Planning stage, the Department assists each Community Council in the preparation of the Council's capital planning submission to the Minister for projects eligible for funding under the Department's Capital Programs.
6. The current capital target assigned to the Department by the Executive Council for 1992/93 fiscal year is not known at this time, but based on historical trends, we can assume for the time being that the Target will be in the range from \$40 - \$46 million.

PHASE II - Resource Allocation - Community Level

1. Phase II consists of:

- i) prioritization of programs and projects for allocation of the Departments anticipated capital budget for 1992/93 and the following four years of the Five Year Capital Forecast.
- ii) consolidation of the Headquarters and Regional Five Year Capital Plans into a Departmental Five Year Capital Plan.

2. Phase II will be conducted in four steps:

- Step 1 Each Regional Capital Program Officer will recommend, to the appropriate Capital Program Director and Regional Superintendent, relative priorities for project needs identified in the Capital Plans for communities in their respective Regions.
- Step 2 Each Program Director will, in consultation with the Regional Program Officers, recommend project priorities on a territorial wide basis for each Capital Program under their direction to the appropriate Assistant Deputy Minister and/or Deputy Minister.
- Step 3 The Deputy Minister, in consultation with each responsible Program Director and with each Regional Superintendent, will evaluate and recommend overall Departmental Program and Project Priorities to the Minister.

Step 4 The Minister will consider the recommendations of the Deputy Minister and approve or otherwise modify program and Project priorities to better respond to the political demands on his portfolio.

3. Step 3 above will be conducted as a business item of a meeting of the Senior Management Committee, which is scheduled to take place in the week of April 23 - 26, 1990.
4. It is intended that Step 4 will be undertaken at a subsequent meeting of the Senior Management Committee of the Department with the Minister present and by way of a verbal and graphic presentation.
5. Following Step 4 each Regional Superintendent and Division Director advises the Community Councils of which they are responsible for capital planning purposes of the current status of the Capital project submissions for their community at this point in the Capital Planning process.
6. The title "Regional Capital Program Officer" refers to the senior Department of Municipal and Community Affairs employee in a Region with the primary responsibility for the delivery of one or more specific Capital Program(s) of the Department.

Following is a listing of the Regional Capital Program Officers and the respective Capital Programs for which they are responsible to assess and recommend project needs and priorities to the Regional Superintendent.

<u>Regional Capital Program Officer</u>	<u>Capital Program Responsibility</u>
Recreation Officer	i) Core Recreation Facilities ii) Additional Recreation Facilities iii) Community Recreation Planning
Municipal Affairs Officer	i) Community Offices (per Public Buildings Program)
Community Planner	i) Urban Planning and Design ii) Land Development iii) Site Development iv) Road Construction (Hamlets and Settlements)
Municipal Engineer	i) Fire Protection ii) Road Maintenance iii) Public Buildings (except Community Offices) iv) Land Management (Granular Materials) v) Water and Sanitation vi) Mobile Equipment

NOTE: The Municipal Engineer assists all of the other Regional Capital Program Officers in preparing a recommended implementation plan for Capital Planning purposes and ensures that appropriate consultation with DPW has taken place with respect to design and construction schedules and cost estimates.

PHASE III - Capital Planning - Regional Level

1. Phase III consists of:

- i) presentation of the appropriate Community Capital Plans by the Minister to Regional Directors and Regional Councils for discussion and comment along with all of the other Capital Programs of the NWT Government.
- ii) referral by the Regional Superintendent of concerns and wishes of the Regional Council and recommendation of adjustments, if desirable, to the Departmental Five Year Capital Plan, to the Deputy Minister.
- iii) presentation by the Deputy Minister of the results of Regional Council consultations to the Capital Program Directors for review.
- iv) formulation of recommended adjustments to the Department Five Year Capital Plan, in consultation with the Capital Program Directors and the Regional Superintendents.

PHASE IV - Resource Allocation - Regional Level

1. Phase IV consists of:

- i) presentation by the Deputy Minister of the expressed concerns and wishes of Regional Councils to the Minister as well as, recommendation of adjustments, if desirable, to the Departmental Capital Estimates Five Year Forecast; and,
- ii) adjustment of the Departmental Capital Estimates and Five Year Forecast in response to Regional Council consultations as directed by the Minister.

2. Following Step 1 ii) each Regional Superintendent and Division Director advises each Community Council, for which they are responsible for capital planning purposes, of the current status of the capital planning submission for their community at this point in the Capital Planning Process.

PHASE V - Capital Planning - Territorial Level

1. Phase V consists of:

- i) Submission of the Departmental Capital Estimates and Five Year Forecast to the Financial Management Secretariat together with the required documentation and substantiation; and,
 - ii) Interdepartmental review of the consolidated Capital Plans of each Capital Program Department by the Interdepartmental Committee on Capital Planning (ICCP) to ensure the overall Capital Plan of the NWT Government is coordinated.
2. The Department of Municipal and Community Affairs is represented on the ICCP by the Director of Community Works and Capital Planning (CW&CP) and the Manager of Capital Planning for the CW&CP Division. Capital Program Directors and Regional Superintendents may be required to provide additional information and/or otherwise assist the Director of the CW&CP Division as the Departments representative on the ICCP.
3. Following completion of the review of the consolidated GNWT Capital Plan by the Interdepartmental Committee on Capital Planning, Regional Superintendents notify each Community Council, for which they are responsible for Capital Planning purposes, of the current status of the capital planning submission for their community. Each Regional Superintendent requests the Regional Director to similarly advise Regional Councils of the communities represented on the respective Regional Council.

PHASE VI - Resource Allocation - Territorial Level

1. Phase VI consists of :

- i) presentation and substantiation of the Departments' Capital Estimates and Five Year Forecast to the GNWT Standing Committee on Finance - by the Minister, with the assistance of the Deputy Minister.
- ii) presentation of the Departments Capital Estimates and Five Year Forecast to the Legislative Assembly for approval - by the Minister, with the assistance of the Deputy Minister.

Fundamental to the application of the process described above is the active participation of Community Councils, particularly during the first two phases. During these initial phases, they are to be given the advice and support necessary for them to be able to identify, schedule, and prioritize projects.

COMMUNITY GRANULAR PROGRAM

OVERVIEW

The Community Granular Program was formally established in 1990/91 to provide stockpiles of granular materials in non-tax based communities at reasonable cost to public and private agencies in an environmentally acceptable manner while conserving the resource. Previously, it existed as a Priority Program from 1985/86 to 1987/88. During 88/89 and 89/90, it was funded to a limited extent by DPW.

The Program does not operate in competition with local commercial enterprises.

Community needs are assessed by reviewing GNWT Programs that require granular materials such as the construction and maintenance of roads, building sites, airstrips, water and sanitation facilities, and by consultation with community officials and other public authorities having jurisdiction, and with the private sector.

The Program includes Investigation, Production and Cost Recovery Phases. Investigation includes the location and estimation of quantities available, and recommendations upon which the community concerned is encouraged to base its Community Plan and Granular Source Management Plan. Production includes the removal of material from its original site to stockpile, with or without screening or crushing. This is usually accomplished through public tender and contract. Cost Recovery includes recovery of the cost of production as the material is removed from stockpile.

Components of the Program are as follows:

Legislation:	Commissioner's Land Act
	Territorial Lands Act
	GNWT Policies
	DPW Directives

Standards:	Unified Classification of Soils
	Material Description
	Material Frost Susceptibility
	ASTM / AASHTO Specifications

Criteria:

- create and maintain a data base inventory
- investigations to locate adequate sources of material in each community
- develop granular material sources
- develop permanent stockpile sites
- provide select granular materials through processing
- provide granular materials through winter hauls
- purchase and install granular processing equipment in appropriate communities
- provide training programs to local people in the operation and maintenance of processing equipment
- plan and co-ordinate production of granular materials for all GNWT programs in the communities
- establish reserves and rights of way
- recover production costs
- provide ongoing training to Hamlet staff in granular management
- restore granular sources at the end of their use
- provide all Territorial Departments with appropriate reference material
- establish standards for granular material.

CAPITAL STANDARDS AND CRITERIA for COMMUNITY GRANULAR PROGRAM

Foreward:

The Engineering Division of the Department of Public Works will ensure provision of granular materials for use in communities throughout the N.W.T. The objective of this program is to provide sufficient quantities of granular materials for all GNWT Capital and maintenance projects and on a limited basis for use by private individuals and other agencies. Some of the Capital projects are the construction of roads, building sites, airstrips and subsidiary developments, water and sanitation facilities, and community maintenance.

The program will be of benefit to many users, including various Federal agencies and private contractors. This program is intended to replace the existing Community Granular Priority Program. It does not conflict with any other programs and will operate under the Territorial and Commissioners Land Acts and Regulations, all GNWT Policies and DPW Directives.

The Department of Public Works will, under the Community Granular Program, undertake the following work:

1. Create and maintain a data base which identifies the demand for various grades of granular material in each community for the next five years.
2. Locate adequate suitable sources of granular material in each community by using airphoto searches, ground investigation and test pit excavation and sampling.
3. Develop sources of granular material by clearing, grubbing and stripping sites, and construction of access roads to these sources.
4. Develop permanent stockpile sites through clearing, grubbing, and establishing a stockpile base in an area that is outside the community and on an area of land reserved for the program.
5. Provide select granular materials through processing granular materials by screening and/or crushing.

6. Winter haul and stockpile granular materials in communities where access to the sources is restricted to winter hauls.
7. Provide training programs to train local people in the operation and maintenance of the granular processing equipment; produce material with this equipment for a number of years as part of the training program and the production of needed material.
8. Purchase and install granular processing equipment in selected communities. After an adequate number of trained operators are available within the community, sell the equipment to a local private individual or business.
9. Plan and co-ordinate all processing and winter hauling of granular material for all GNWT projects in the communities.
10. Prepare and administer management guidelines for granular sources and stockpiles. This management could involve the establishment of reserves where critical supply conditions exist and security of the source and stockpiles is required.
11. Provide granular materials to users in accordance with their needs at the cost to the program.
12. Initiate and promote ongoing training for Hamlet staff with regards to methods and procedures of granular source development, use and restoration.
13. Restore granular sources at the end of their use to an environmentally acceptable state.
14. Provide all Territorial Departments with reference information regarding material resources in all communities for use in specific construction projects.
15. Liaise with Federal Officials to complete joint-shared projects involving granular material supply and processing.
16. Establish minimum standards for granular material to be used in construction undertaken by DPW.

Program Statement:

The GNWT shall provide the capital resources for identifying, developing, and restoring granular sources and stockpiling, processing and managing granular supplies such that the required materials are available when required for planned community development projects, ongoing maintenance and private use, at a reasonable cost.

Legislation:

Territorial and Commissioners Land Acts and Regulations, GNWT Policies and DPW Directives.

Standard:

The Engineering Division of DPW shall, in conjunction with prospective users, develop granular material standards which are appropriate for the proposed end use of the material.

The granular material standards will include information on the following topics:

1. Classification of Soils
 - Field classification
 - Laboratory classification
2. Material Description, Specifications and Uses
3. Material Frost Susceptibility

The Material Specifications that apply shall be the latest version of the AASHTO Specifications, as listed below:

- | | |
|---|------------------|
| - Embankment | AASHTO M57 |
| - Subbase | AASHTO M57 |
| - Base | AASHTO M147 |
| - Surface | AASHTO M147 |
| - Course Aggregate for Portland Cement Concrete | AASHTO M80 |
| - Aggregate for Bituminous Surface Treatment | AASHTO M283, M43 |
| - Aggregate for Bituminous Paving Mixtures | AASHTO M29 |

The Engineering Division will develop the standards, specifications and procedures governing the production, handling, storage, measurement and release of stockpiled granular materials.

Criteria:

1. This program will be implemented in all N.W.T. communities where:
 - a. Community plans indicate a need for granular materials,
 - b. There are no existing public or private producers currently filling this need at a reasonable cost.
 - c. There is a requirement to locate, develop, transport, produce or manage the required materials.
2. The Community Granular Demand will be analyzed as three separate but related parts. These parts are:
 - a. An analysis of the material requirements for each type of facility built.
 - b. A long term demand analysis based on the GNWT 5 Year Capital Plan, 20 year needs assessments and any long term plans of other agencies that can be located.
 - c. A short term demand analysis will be completed for each year and community that a winter haul or other granular production is planned. This will be done through discussions with the most common users of material, DPW, DOT, NWT Housing Corporation and Transport Canada.
3. The identification of adequate sources under this program will be divided into two categories and each category handled in three phases. By definition, adequate sources will supply the forecast requirements for the next ten years in the community.

The granular investigations undertaken by this program will be divided into the three phases described below.

- a. PHASE 1 - Office search of existing studies and if necessary, an airphoto study of the area to locate probable sources.
- b. PHASE II - Preliminary field testing and sampling of all probable sites to determine the general quality of the source material.
- c. PHASE III - Field testing to prove the quality and quantity of the source, the possibility and need for processing and the preparation of Management plans.

Investigations under this program will also be divided into two categories and their handling will be as follows:

- a. Communities with no known source will be prioritized and investigated at a rate of 5 communities per year until completed.
 - b. Communities with a known but inadequate source will be prioritized and investigated at a rate of 6 communities per year on an ongoing basis.
4. Permanent stockpile sites will be established in all communities where granular material will be processed or winter hauled, under the following criteria.
- a. The site shall be a minimum of 1 km. from the edge of the community.
 - b. The site shall be a minimum of 2 ha. with a minimum dimension of 100 m.
 - c. The site shall be located to take into consideration any possible visual screening.
 - d. Access to and from the site will be considered in the selection of its location.
 - e. The site and access will be covered by a reserve in the name of DPW, Community Granular Program.
5. Permanent stockpile sites will be developed under the following criteria.
- a. The site will be cleared and stripped and the debris piled in an organized manner out of the way.

- b. A drainage survey and any required drainage of the site will be completed prior to use.
 - c. The access road and pad base will be completed one year prior to use of the site.
 - d. A site survey will be completed tying into the local legal surveys to establish the correct boundaries for the land reserve.
 - e. Traffic control and security of the site will be constructed as part of the site development.
6. Where granular resources are limited and conservation or management is necessary, a list will be created on or about May 1, in any particular year, stating the allocation of the material. This allocation will be made on the basis of the following priorities:
- a. Construction of new public facilities.
 - b. Maintenance of public facilities.
 - c. Construction of private facilities.
 - d. Maintenance of private facilities.

After the May 1 deadline, the remaining material will be made available on a first come first served basis depending on the time of the request.

In addition, the use of costly high quality materials shall be restricted to projects where that high quality material is necessary. For example, a small source of concrete aggregate or select surfacing would be reserved for only those types of projects.

Control of this restriction could involve:

- Applying for official reserves
- Posting locations and other forms of security
- Advising all contractors, community administrators and other government departments of the need for conservation of that specific material.

7. A chargeback process will be established to handle the recovery of funds created by the sale of granular material. All costs associated with the development, hauling or production, storage and handling of the material in a particular community will be charged back to the end user of the product.

The Granular Recoveries portion of this program will operate under the following criteria:

- a. All costs of developing the source and stockpile site, including engineering and supervision of these works will be recovered at a rate based on the total cost divided by the estimated 10 year material demand for the community.
- b. The value of the material produced or winter hauled in a particular year will be calculated to include all production and supervision costs. This total cost will be prorated over the total stockpile volume of material hauled or produced in that particular year.
- c. If material remains from previous production or hauling, the cost of the material will be combined through a moving average calculation.
- d. A Service Contract to handle the security, and allocation of the stockpile will be let in each community where material has been hauled or produced. This service contract will be paid based on 10% of the selling price of the material dispensed. This Contractor will also be the only one authorized to dispense the material.
- e. A complete financial system will be set up to handle these recoveries and shall include:
 - 1) Truck load tickets
 - 2) Requisitions for material
 - 3) Monthly Summaries
 - 4) Invoicing requests.
- f. Inventory control will be maintained through annual surveys of the stockpiles.

Excerpt from

Technical Section

of

Granular Report

1. INTRODUCTION

The geotechnical studies undertaken by the Community Granular Section are an integral part of the Community Granular Program. The goals, principles, definitions and methodology of these reports are discussed in this section.

1.1 General

The Community Granular Program, Engineering Division, D.P.W., provides the capital resources for identifying, laboratory testing, developing, and restoring granular sources for all non-taxed based communities in the N.W.T. The objective is to process, stockpile, and manage granular supplies to ensure materials are available for planned community development projects, ongoing maintenance, and private use, at a reasonable cost.

To meet this objective, geotechnical investigations are planned for various communities throughout the N.W.T. and are prioritized on the basis of the granular needs in the communities. These needs are derived through an analysis of the 5 year capital plans and the 20 year capital needs assessment of every GNWT Department, the N.W.T. Housing Corporation, the Federal Government and where available, the private sector, as of November, 1989. Highly speculative needs such as resource development projects (i.e. oil and gas) are beyond the scope of these studies.

The intent of this report is to precisely define the community's available granular resources and its granular needs over a 20 year horizon and develop options for the management of those resources that ensure the community's long term needs are met. The report and recommendations will enable the community, through the consultative process, to develop a comprehensive Granular Resource Development and Management Plan that will provide control of the extraction, development, use and restoration of granular resource areas.

1.2 Geotechnical Investigation Procedure

This granular materials study is a multi-phased investigative and assessment process that may be broken down as follows:

Terrain Analysis

- regional setting
- geology and geomorphology
- drainage
- permafrost distribution

Resource Description and Assessment

- review of pertinent information
- air photograph interpretation
- ground reconnaissance and sampling
- material quantity assessment
- material quality assessment
- ground ice and permafrost assessment
- evaluation of all sources
- access routes
- source summary

Granular Needs Assessment

- granular material breakdown
- 5 year needs assessment
- 20 year needs projections
- needs summary

Recommendations

- comparison of resources and needs
- development of options
- development of estimates
- selection of options

1.3 Specifications and Terminology

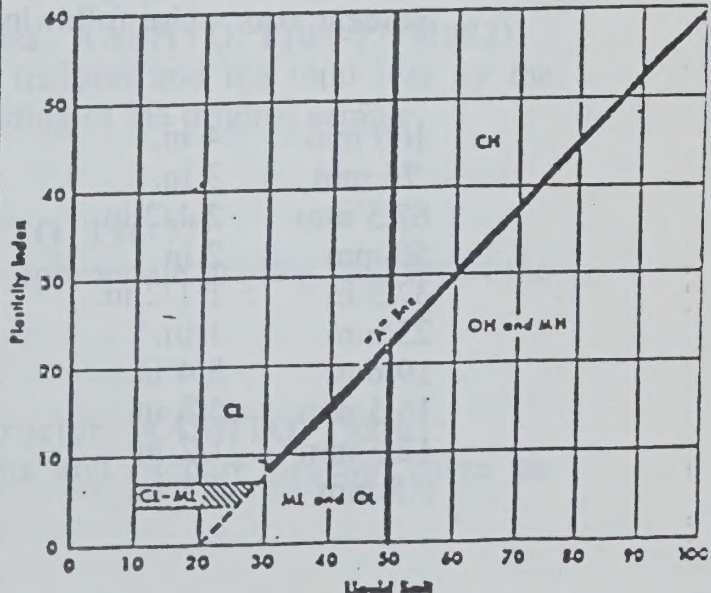
A number of systems have been devised for classifying granular materials that are based on soil characteristics and engineering properties of the material. The Community Granular Section uses the following standards, criteria and specifications to describe the material in the granular sources discussed in this report. In addition, a Glossary of Terms is to be found following Section 8.

1.3.1 Classification of Soils

The Unified Soil Classification System (USC) is used to identify various types of soils through visual description in situ and in the laboratory and through tests such as Atterburgh Limits and sieve analysis. The USC system is shown on the following page.

Unified Soil Classification System

1.3.1

Major divisions		Group symbols	Typical names		Laboratory classification criteria		
Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravel, gravel-sand mixtures, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^3}{D_{60} \times D_{10}}$ between 1 and 3		
		GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW		
		GM*	d	Silty gravel, gravel-sand-silt mixtures	Atterberg Limits below "A" line or P.I. less than 4		
			s		Atterberg Limits above "A" line with P.I. greater than 7		
	Gravels with fines (Appreciable amount of fines)	GC	Clayey gravels, gravel-sand-clay mixtures		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^3}{D_{60} \times D_{10}}$ between 1 and 3		
				Not meeting all gradation requirements for SW			
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		Limits plotting in border zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols	
			SP	Poorly graded sands, gravelly sands, little or no fines			
		Sands with fines (Appreciable amount of fines)	SM*	d	Silty sand, sand-silt mixtures		Atterberg Limits below "A" line or P.I. less than 4
			s	Atterberg Limits above "A" line with P.I. greater than 7			
	SC	Clayey sands, sand-clay mixtures					
Fine-grained soils (More than half of material is smaller than No. 200 sieve)		Silt and clays (Liquid Limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
		Silt and clays (Liquid Limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
Highly organic soils		PT	Peat and other highly organic soils		Plasticity Chart		

Determine percentages of sand and gravel from gradation curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:
 Less than 5 per cent..... GW, GP, SW, SP
 More than 5 per cent..... GM, GC, SM, SC
 5 to 12 per cent..... Borderline cases requiring dual symbols.

Plasticity Chart

1.3.2 Engineering Properties of Materials

Granular materials have been separated into various "types" for the purposes of this report. Each type is based on the intended end use of the material and conforms to the American Association of State Highways and Transportation Officials (AASHTO) specifications, as follows:

Type	Specification
Embankment	AASHTO M 57-80
Sub-base	AASHTO M 57-80
Base	AASHTO M 147-65(80)
Surface	AASHTO M 147-65(80)
Concrete Aggregate - fine	AASHTO M 6-81
- coarse	AASHTO M 80-77(92)

All granular material samples are subjected to standard laboratory tests to ensure conformance with these specifications. The tests are:

- **Washed Sieve Analysis: AASHTO T11-82:**

Report grain size analysis on standard form showing all calculations, eg. original dry, dry after washing amount retained per sieve and percent error. Use following sieve nest.

100 mm	4 in.	4.75 mm	No. 4
75 mm	3 in.	2.36 mm	No. 8
67.5 mm	2 1/2 in.	2.00 mm	No. 10
50 mm	2 in.	1.18 mm	No. 16
37.5 mm	1 1/2 in.	0.60 mm	No. 30
25 mm	1 in.	0.425 mm	No. 40
19 mm	3/4 in.	0.300 mm	No. 50
16.5 mm	5/8 in.	0.150 mm	No. 100
12.5 mm	1/2 in.	0.075 mm	No. 200
9.5 mm	3/8 in.		

- **Dry Sieve Analysis: AASHTO T27-82:**
Sieve down to No. 4 (4.75 mm) using sieve nest indicated in specification. Prepare grain size curve on standard form.
- **Lab Crushing:**
Crush to required maximum size using laboratory jaw crusher. Size will be given on sample information.
- **Atterberg Limits: AASHTO T89-81 Method A. T90-81:**
Report summary list of sample numbers with liquid limit, plastic limit, and plasticity index. Report on standard form.
- **Visual Description and Classification:**
Give a brief visual description of sample content as per example. Classify the material as per Unified Soils system and AASHTO system including group index. Report on standard form.
- **Natural Moisture Content: AASHTO T265-79:**
Supply summary list showing sample number and moisture content. Also complete lab data copies.
- **Magnesium Sulphate Soundness, AASHTO T104-77 (1982):**
Report the loss on each coarse fraction and the total loss by the weighted average based on the grading of the original sample.
- **Los Angeles Abrasion, AASHTO T96-77:**
Depending on the sample, use the appropriate grading, and report the loss as a percentage.
- **Modified Proctor Standard Proctor, AASHTO T99-81:**
Report results of five (5) points and prepare proctor curve on standard form.

- **Petrographic Analysis, MTC LS-609:**
Using coarse aggregate report PN number and flakiness index.
- **Fractured Face Count, MTC LS-607:**
Report as percentage of original sample mass.
Refer to AASHTO T4-35, Section 2.
- **Flat and Elongated Particle Count, MTC LS 608:**
Report as percentage of original sample mass.
- **Hydrometer Analysis: AASHTO T88-81:**
Supply all lab data and grain size curve. Plot results of grain size on Contractor's standard grain size distribution curve.
- **Washed Sieve Analysis:**
Minus 0.075 mm: AASHTO T11-82.
Organic Content: AASHTO T267.

It is important to note that all samples may not have to be subjected to the full range of test procedures.

It should be noted also that ground thermal analysis and the engineering properties of permafrost unique to northern periglacial environments are taken into consideration in all situations.

1.3.3 Environments of Deposition

The properties of any granular material vary with its gradation, moisture content, vertical position in relation to the surface of the ground, and geographic location. Time and climate influence the weathering process of mechanical and chemical disintegration that breaks the material down into progressively smaller particles. The term gradation refers to the relative size of these particles in a deposit.

Size distribution is related to environments of deposition that indicate the texture and composition of a granular deposit. The amount of each size grouping in a deposit is one of the major tools used in judging, analyzing, and classifying a source for use as a construction material. Granular deposits contain particles ranging in size from boulders through clay, as indicated below.

203.2 mm (8 in.)	71.6 mm (3 in.)	19 mm (0.75 in.)	4 mm (0.16 in.)	2 mm (0.08 in.)	0.42 mm (0.02 in.)	0.075 mm (0.003 in.)	
Boulders	Cobbles	Coarse Gravel	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt & Clay (Fines)

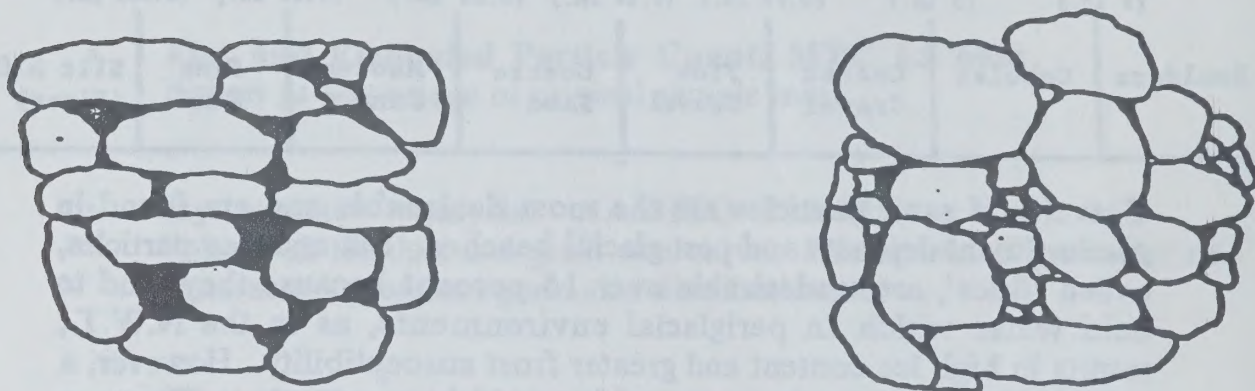
Gravel and sand particles are the most desirable and are found in glacio-fluvial deposits and post glacial beaches. Silt and clay particles, called 'fines', are undesirable over 15 percent because they tend to hold water which in periglacial environments, as in the N.W.T., results in high ice content and greater frost susceptibility. However, a lower limit of 5% is often acceptable to aid in compaction. Fines are often found in deltaic and lacustrine deposits, some fluvial sediments, and tidal flats. Post glacial/fluvial processes during the Quaternary period have also influenced the type of gradation in granular sources in the N.W.T.

Mechanical weathering is the dominant process acting on the rock strata of the precambrian outcrops throughout the N.W.T. Since the regolith produced from the weathering process occur "in situ", most granular deposits in the N.W.T. are "poorly graded" with a high percentage of "oversized" particles.

The suitability of a deposit for construction purposes is directly related to the particle distribution or grain-size curve. This curve indicates if a deposit is "well-graded" or "poorly graded", two terms that are used extensively in this report.

A "well graded" granular deposit has an equal amount of each gravel and sand size and little or no fines. These deposits are referred to as "clean" and are excellent quality materials for "pitrun" construction purposes. Eskers and raised beaches are prime examples of "clean" deposits.

A "poorly graded" granular source has an excess of some particle sizes, a shortage or lack of others, or has nearly all particles the same size. These sources need processing to improve and upgrade their quality. Screening and washing can be used to remove undesirable particle sizes. Talus slopes, alluvial fans, and varved clays are prime examples of this type of deposit found in the N.W.T.



Poorly-graded materials with all particles the same size or with a lack of certain particle sizes (left drawing) have more voids and are less stable than well-graded materials where the voids are filled by the smaller particle (right drawing).

1.4 Volume Estimates

Volumes of granular material sources as described in this study are classified as being proven, probable, or prospective.

A **proven** volume is one where existence, extent, thickness and quality is supported by ground truth information such as a test-pitting, exposed stratigraphic sections, bore hole drilling, and aggressive sampling and ground truth reconnaissance.

A **probable** volume is one whose existence, extent, thickness and quality is inferred on the basis of direct and indirect evidence such as airphoto interpretation, geophysical data, terrain analysis, and limited sampling and ground truth reconnaissance.

A **prospective** volume is one whose existence, extent, thickness and quality is suspected on the basis of limited direct evidence, such as airphoto interpretation, remote sensing information, or imaging radar techniques. There is no sampling or ground truth reconnaissance.

1.5 Restoration and Regulations

Pit planning, design, and restoration are important aspects of granular resource development. Environmentally, the development of any granular sources offers the potential for drainage and erosion problems, habitat destruction, and the disturbance of wildlife. In many communities in the N.W.T., excessive scarring of the surrounding terrain is a major concern. These reports take into account the economic and environmental factors of pit abandonment and reclamation. Guidelines to minimize the impact of pit development and quarry operations are available in the INAC (1982) publication "Environmental Guidelines Pits and Quarries". At all stages of pit planning, design and operation, methods that ensure final pit restoration are stressed.

Permafrost can be expected throughout the N.W.T. and results in a variety of environmentally sensitive problems related to pit abandonment and restoration; thus pit development in permafrost environments must be planned well in advance and special techniques used during the extraction of material.

Territorial land use regulations are to be followed in all development plans, without exception, especially in the areas of land use permits, explosives, and pit abandonment.

PROBLEMS WITH BURIED SEWERS

IN THE

TOWN OF IQALUIT

NORTHWEST TERRITORIES

**BY: A. J. HANNA,
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DECEMBER, 1990

1.0 INTRODUCTION

In recent years numerous problems have been experienced in buried sewer pipes in Iqaluit. This presentation will deal with the problems, some of the design changes, some of the assumptions and some of the current research being done on the issue, as well as some of the related problems throughout the buried infrastructure.

1.1 Background

1.1.1 Community of Iqaluit

The Town of Iqaluit, the largest community in the Baffin Region of the Northwest Territories, is located on the south end of Baffin Island, about 2060 Kilometers north of Montreal, and 2275 kilometers east of Yellowknife. The community's geographical coordinates are 64 44 north latitude and 68 31 west longitude. It lays in a continous permafrost zone and is above the tree line.

The present community is near the site of a traditional Inuit fishing camp. A United States Air Force base was established in the community in the early 1940's and community development was centered around military activity until the closure of the DEW Line site in the late 1960's. Since that time the community has grown as a regional government centre.

The Town is in a phase of major development as a result of continuing regional development in the Baffin Region, and the construction of a Forward Operating Location adjacent to the airport. Government of the Northwest Territories Bureau of Statistics estimate the June 1989 population to be 3,126. Population estimates to the year 2008 are from 4,377 to 5,200.

In 1971 the community was named The Hamlet of Frobisher Bay. It gained Village status in 1974 and Town status on October 1, 1980. On January 1, 1987 the Town was renamed Iqaluit, after the name of the traditional fishing camp, which it now encompasses. It's development and community responsibilities have evolved to the point where the basic infrastructure management and planning responsibilities now reside with the Town.

Basic infrastructure components are water supply, sewage disposal, solid waste disposal, roads and municipal buildings.

1.1.2 Water and Sewer Infrastructure

The responsibilities for management of the piped water and sewer systems were transferred to the Town on April 1, 1989. The GNWT Department of Public Works, who has had responsibility for the system for a number of years, still operates it on behalf of the Town. This will continue until the Town phases in their own operations.

The water in the Towns' system is heated to between 5 to 8 degrees C. and is constantly recirculated where applicable. Bleeding in some instances is required to provide freeze protection to not only the water mains, but, to the sewer mains and services as well. Primary sources for heating the domestic water are through high temperature hot water provided by the Northwest Territories Power Corporation and distributed by the GNWT Department of Public Works and oil fired boilers in two strategic locations in the system.

The piped water and sewage system consists of approximately 45 kilometers of trunk lines, distribution lines, service lines and close to two hundred access vaults, manholes and water trunk main access points. Pipe materials consist of asbestos cement, ductile iron, C.M.P., mild steel and series 45, 60, 80, 100 and 160 H.D.P.E. The manholes are of insulated concrete construction, the access vaults are of insulated steel construction and the water trunk main access points are HDPE with insulation blankets installed around the interior appurtenances.

At the present time the piped water and sewer system constitute approximately 2/3 of the system while it is estimated that the trucked water and sewage services constitute the remaining 1/3.

2.1 Noted Problems

Over the last two years, the Town has begun to play a major role in infrastructure planning and development in the community as a result of the "Turnover/Acquisition Agreement" with the GNWT. During this time a number of problems with the system has come to light. These include various forms of pipe collapsing in High Density Polyethylene (HDPE) sewer mains and services, crushing of pipe insulation, wrinkling of pipe insulation wrap, wall and base distortions in access vaults (AVs) water in sewer pipe, water pipe and AV insulation, broken hydrant tees in hydrant AVs and protruding sewer service connections into the sewer mains. Some of these problems were readily explainable and relatively easy to overcome, whereas, others problems require further evaluation and research.

It does appear however, that some of the problems being experienced are due to the injection of water into the immediate regions of the buried infrastructure. Although the sources of this water have not been completely ascertained it is believed that they originate from; water system leakage through, flanged connections at the AVs, sheared HDPE stup-end fusions at AVs, leaking water service connections and ground water entering the insulation cavities through pipe joints and service insulation kits.

2.1.1 Access Vaults

In recent design the Iqaluit water and sewer system has incorporated both water and sewer systems in common AVs.

Initially it was noted that water was inexplicably entering the AVs from around the rim of the lid. It was also noted that when contractors were making wall penetrations for tying in new pipes into existing AVs, that the insulation cavity between the walls of the AVs appeared to be under water pressure.

During the winter of 1989/90 two hydrant tees inexplicably broke inside AVs and HDPE water pipes were sheared off just outside the AVs. In the 1989 and 1990 construction seasons the contractors and GNWT DPW personnel also complained of apparent wall distortions in existing AVs which made joining of existing spool pieces inside these AVs extremely difficult.

Through subsequent observations and review of the access vault design it was determined that water from various determined and undetermined sources was getting into the insulation of the AVs through the designed wall penetrations for sewer and water mains. (figure 1) This water could then travel virtually unrestricted throughout the entire AV insulation, water pipe insulation and sewer pipe insulation. It is believed that many if not all of the noted problems in the AVs were due to the action of this water freezing. (see drawing AV details)

Pressures; whether ground water pressures or other types of pressure, were exerting enough force to cause water to exit through the rim into the AV. This pressure, or possibly water freezing within the insulated base and walls, appears to have been the cause of wall distortions and bulging in the base of the AVs which have provided enough uplift force to the hydrant tee support to break the cast iron tees in the previously noted instances. It is believed that this strain possibly caused the shearing of the HDPE pipe attached to the AVs

The lack of a water restraining device, for the pipe penetrations in the AV walls, provides the conduit for related problems to promulgate in various other locations far removed from the region of a single existing problem.

It is believed that this problem has been overcome in the new design which the municipality, in consultation with its consultants, have adopted. It is very simple in concept and relatively inexpensive to construction.(figure2) In the new design the outer sleeve of the wall penetration which used to terminate at the outer wall of the AV has simply been extended and welded to the inner wall of the AV. Consideration was given to frost following the steel sleeve and causing potential freezing of the pipes. In evaluating this concern it was felt that the internal vault temperatures, normally in excess of 5 degrees celsius due to the heat from the

water and sewer system, would overcome the external freezing ground temperature. The potential for freezing of the pipes inside the AVs was considered remote and should the freeze path advance to the proximity of the pipes it could readily be intercepted inside the AV.

The challenge now is the means to devise a method of addressing the related problems in the existing AVs. Attempts at this have been unacceptable to date. (figure 3)

Another design consideration, which was utilized to prevent uplift forces in the base of the AV from breaking hydrant tees, (figure 4) was the use of sacrificial threads in the adjusting plate of the hydrant tee support and a compressable block. In most 1990 consultant designs this was achieved by threading an HDPE adjusting plate. This design has the advantage of being able to be used in existing AVs which are not readily conducive to easy interruption of the water path. In actual fact, operating personnel have chosen to remove the supports entirely, except, in instances where the support is critical.

2.1.2 Service Connections

During the winter months there has been an historic chronic problem with sewer and water service connection blockages. The problems appear to be three fold in the sewer services and two fold in the water services.

Firstly, during the repair process it has been noted that the sewer service lines and water carrier pipe have been crushed in a variety of configurations. The crushing aspects will be dealt with later in this paper.

Secondly, a subsequent camera inspection carried out this past summer has identified numerous service connection protrusions into the sewer mains. In certain instances the service pipe has protruded entirely across the sewer main and has been the cause of sewer backups in the mains as well as in the services. (see old detail figure 5)

Thirdly, when the sewer service backed up, in most cases the service line became frozen. The difficulty then became thawing the line where it made the 90 degree bend to drop into the sewer main. These problems only tended to happen in the winter when the ground was frozen and digging was virtually impossible or very costly and time consuming with the available equipment.

The problems with the water service connections have been; the crushed carrier pipe, which is normally insulated and carries the water service supply and return lines as well as the heat trace cable, (figure 6) and the inability to readily thaw the service lines should they become frozen. Again, digging of any sort to reinstate service was very difficult. (see old detail figure 7)

Through the design review process with the Towns' consultants a number of relatively simple design changes (see **new sewer service connection detail figure 8**) were made which would make unthawing of the services substantially easier and less expensive. The changes to the sewer service connection involved change to the sewer service saddle as well as a change to the position of its entry into the sewer main. Instead of utilizing a saddle with a slip joint, a saddle with a flanged connection to the HDPE sewer service line was used. This saddle was then positioned at 45 degrees off vertical instead of the traditional vertical drop. These two changes should overcome the difficulties of service line protrusions into the sewer main as well as providing for easier thawing of the 45 degree elbow as opposed to the 90 degree elbow. A flat service connection was considered, but, discarded due to the potential for freezing should the main be surcharged for a duration whereby freezing potential may occur in the service line outside the main line heat zone of influence.

The water service connection to the main was handled in a similar manner, (see **new water connection detail figure 9**) whereby, the mainstops would be installed at 45 degrees off vertical and the service pipes simply attached to the mainstops. This has made unthawing significantly easier and has potentially reduced the cost of installation by deleting the costly riser valves and associated assembly kits.

In making the decision to delete these valves, a survey of operational use of the existing configuration was undertaken and it was discovered that operational staff could not remember using the riser valves for any purpose. It was found that instead, should repairs to the service become necessary the main was temporarily shut down. Should major service repairs be necessary, excavation to the main as opposed to the riser was not considered to be a more necessary need than the ability to unthaw the service. Evaluation of historical operational related problems indicate that the frequency of service freezes far out number the problems where the riser valve use would become necessary. A coined phrase of the north "what can freeze does" must always be recognized in cold regions design.

The challenge now is the repair and maintenance of the services that still exist.

2.1.3 Pipe Collapses

An investigation was initiated to identify the causes of pipe failures in the Town's sewer system. The investigation was to address certain factors that could be contributing to the failures, including:

- geotechnical causes such as ice lensing beneath the pipes,
- careless construction practices,
- design factors such as insufficient pipe strengths to resist actual external and internal stresses.

The ultimate objective was to determine the nature of the pipe failures and to identify causes so that mitigative measures could be developed.

2.1.3.1 1989 EXCAVATIONS

Excavations were made to replace collapsed or backgraded sewer pipe at several locations during the 1989 Rehabilitation Program. Observations were made at nine of these sites. The locations are shown on Figure 10, a key plan of all of the Iqaluit water and sewer system. It can be seen that the problems are distributed throughout the system. Observations made at the sites between August 8 and October 1, 1989 are summarized in Table 1. This summary includes observations of the total pipe system including jacket, insulation, and HDPE pipe, as well as the ground conditions in the trench. The affected portions of pipe were typically relatively short. Site 6 was the only one where an extensive section of pipe was damaged. Selected sites are described as follows:

Site 1

The pipe insulation and jacket were all ovalled to some extent. The long axis of the oval was inclined at about 30° to the horizontal, projecting towards the bottom of the water pipe. There was considerable wrinkling on the upper portion of the jacket and some underneath. The jacket on the adjacent water pipe was also wrinkled.

Site 2

The whole pipe system (jacket, insulation and HDPE pipe) appeared to be pushed in from beneath. There was a major wrinkle along base of pipe.

Site 6

There was minor wrinkling on the sewer and water pipes. There was some ovaling of the jacket and insulation, however, the pipe was ovalled to a greater extent. There was considerable separation between pipe and insulation and major tension cracks. Another portion of the failure showed the separation within the insulation with a good bond between insulation and pipe. The long axis was inclined about 30° to the horizontal and projected towards the water pipe.

Site 9

The outer jacket and insulation appeared in generally good condition. There was an opening at a joint sleeve near the collapsed pipe. The pipe was completely crushed inside the insulation with ice inside the void. There was minor cracking and compression of the insulation.

It should be noted that this sewer pipe had not been in use since the operational problem occurred in the winter. At all other sites, some flow had been maintained in spite of the considerable restrictions.

2.1.3.2 Ground Observations

The ground observations are also presented in Table 1. The main observations are summarized as follows:

- There appeared to be an obvious "pipe zone" of better quality backfill immediately around the pipes at all sites, except Site 4.
- At three sites, the water and sewer pipes were found to be very close such that proper compaction between or around the pipes would have been almost impossible.
- Groundwater was encountered at all sites. At several sites, particularly Sites 1, 2, 5 and 6, concentrated seepage was noted in the vicinity of the pipe collapse.
- The extent of thaw beneath the pipes varied from essentially nil to greater than 0.3 m, however, this detail was not obtained at all sites.

2.1.3.3 Apparent Failure Modes and Causes

A review of the 1989 data and that from previous observations suggests that there are two basic types of pipe failure mode occurring. The most common one appears to be due to pressure which develop outside the jacket. The other mode may be initiated by pressures outside the system but the pipes are subsequently affected by pressures developing inside, between the insulation and pipe.

Pressure Outside the Jacket

At Sites 1, 2, 5 and 7, and at three previous failures, it is evident from the condition of the jacket and the common form of the jacket/insulation/pipe system, that considerable external pressure has caused the collapse. These types of failure mode due to external pressure are illustrated on Figure 11. It is probable that these types of failure are gradual, with an increase in deformation each winter. Eventually the pressures cause sufficient deformation, especially in Type A2, that can effectively pinch the pipe closed.

It is believed that these failures are caused by excessive hydrostatic pressures developed during freezeback of the active layer. Considerable pressure could occur around the pipes if a "closed system" develops during freezeback, as presented in the following paragraphs.

Figure 12 illustrates the thaw and freezeback conditions expected in the vicinity of the pipes.

The pressures that could develop within a 3-dimensional, completely closed system are very difficult to predict. Clearly the restraint is the frozen cap over the system. If the soil in the cap was saturated at the time of freezing the strength can be considerable. As freezing in the closed system continues, the maximum pressures are exerted on the pipes which, being a heat source, will be the last to freeze.

Pressure Inside the Jacket

Site 9 revealed one of the most dramatic pipe failures observed. It would appear that the ice had just expanded to squeeze the pipe off. However, it is difficult to imagine how this could occur inside the insulation of an operating sewer line, especially on the underside where the sewer would have been warmest.

Based upon data from Sites 3, 6 and 9, the failures are sketched on Figure 13. It is believed that the failure process may be initiated by external pressure (e.g. overstressed during compaction, lack of lateral support, freezeback pressures) resulting in the crushing of the pipe, as evidenced by the radial tension cracks in the insulation. To this extent the failures at Sites 3 and 6 may be similar to those described in the previous section. The deformation of the HDPE pipe appears to be permanent while the insulation and jacket separate from the pipe and are able to regain their form. This of course raises the question as to whether or not the initial loading was external.

It was not confirmed during excavation whether the insulation had returned to its original form while under the full soil loading or if it only occurred as the load was released. If the system was initially squeezed by external loading, it would take some pressure to push the insulation and jacket out to its original form while still covered by the soil. Pressure inside the jacket could possibly occur during freezeback of water that has entered the system. It is thought that this water could be originating from two possible sources - leaking water main connections or groundwater entering through a damaged jacket or inadequate joint seal.

2.2 Monitoring Program

Based on the above observations and preliminary conclusions, it was obvious that monitoring would be required to confirm the existence of such pressures. A series of thermistor strings and piezometers were installed (Figure 14) in the fall of 1990 and more are planned for the 1991 construction season.

Preliminary observations confirm that the heat from the water and sewer pipes delays freezeback around the pipes and that a closed system can easily occur. Some limited excess pressure has been noted at one location.

With more instrumentation to be installed and a detailed review of sewer camera video tapes to be undertaken, it will be another year before some firm conclusions will be available.

TABLE 1
QUALITY SEWER PROBLEMS
1989 REPLACEMENT SECTIONS
HARDY BBT LIMITED ASSESSMENT

LOCATION	YEAR INSTALLED	AFFECTED LENGTH (m)	JACKET CONDITION	INSULATION THICKNESS (mm)	INSULATION CONDITION	SEPARATION FROM PIPE	COLLAPSED PIPE DIMENSIONS	PHOTO SKETCH	PIPE ZONE CONDITIONS	BEDDING THICKNESS AND MATERIAL	GROUNDWATER	EXTENT OF THAW BELOW PIPE (m)	NATURAL SOIL BASE	COMMENTS
1. AV 200 to 201	1985	6.7	wrinkled, peeling off	50 sides 55 bottom	single crack	none at ends, some at mid-section	180 x 210	Photo 1, Figure 2	silty, gravelly sand, saturated	130 mm silty gravelly sand	considerable inflow at collapse	0.13	black clayey silt	water pipe directly cover sewer pipe-jacket of water pipe also wrinkled.
2. NH 81 to 82	1979	4.5	severe wrinkle under; rips off easily - heat shrink sleeves loose.	50 sides 60 top	saturated, minor crack, eroded - see comments.	very minor one side	125 x 250	Photo 2, Figure 2	boulders and cobbles near but not in contact	pit-run sand and gravel	see comments		—	appears water flowing beneath pipe eroded bottom of insulation.
3. AV 300 to 303	1987	2.7	generally good	45 sides 50 top and bottom	dry, single crack	30 mm upper half	150 x 230	Photo 3, Figure 4	clean granular	gravelly sand		0.1 to 0.15	no silt	sewer operational but pig could not pass.
4. NH 53 to 52	1979	3	good but relatively easy to remove.	60 side 55 bottom	numerous cracks, different pattern from	some, also within insulation	180 x 215	--	very little sand over or around pipes.	none, pipe directly on silt			ice rich silt	water and sewer at same depth 0.2 m apart; background pipe.
5. AV 205 to 206	1985	3	generally good, wrinkled at collapse	45 sides 55 top and bottom	OK	none	80 x 225	Photos 4, 5, and 6, Figure 2	sand	100 to 150 mm sand, rock under pipe	considerable inflow	0.1 to 0.15	black silt	jacket of water pipe also wrinkled.
6. AV 206 to 307	1985	66	badly wrinkled	30 side 50 bottom	four major cracks	30 mm upper 35 mm lower	140 x 235	Photos 7, 8, and 9, Figure 4	gravelly sand	up to 100 mm gravelly, coarse sand	considerable inflow	0.3 m	silt at 0.3 m below pipe	water pipe 0.1 m to side of sewer pipe - probable lack of launch support.
7. NH 93 to 92	1979	4	good upper, severe wrinkle under	50	cracks on bottom	minor in lower portion	--	Photo 10, Figure 2	coarse sand	100 to 150 mm coarse sand			coarse sand	
8. NH 72 to 71	1979	3	looks worn i.e. small indistinct	--	saturated locally at service and for 1 m each side.	--	--	Photo 11	gravelly sand	none apparent, formed in-place insulation under the pipe.			gravelly sand	in service location.
9. AV 4 to 3	1984	12	opening at adjacent joint sleeve	30-50 sides 45 top and bottom	cracks and local compression	complete over lower half	total collapse	Photo 12, Figure 1	gravelly sand	gravelly sand similar to native sand	considerable water in trench		frosts	failure coincides with transition between native layer and permafrost.

AM/BB/00114



FIG 3

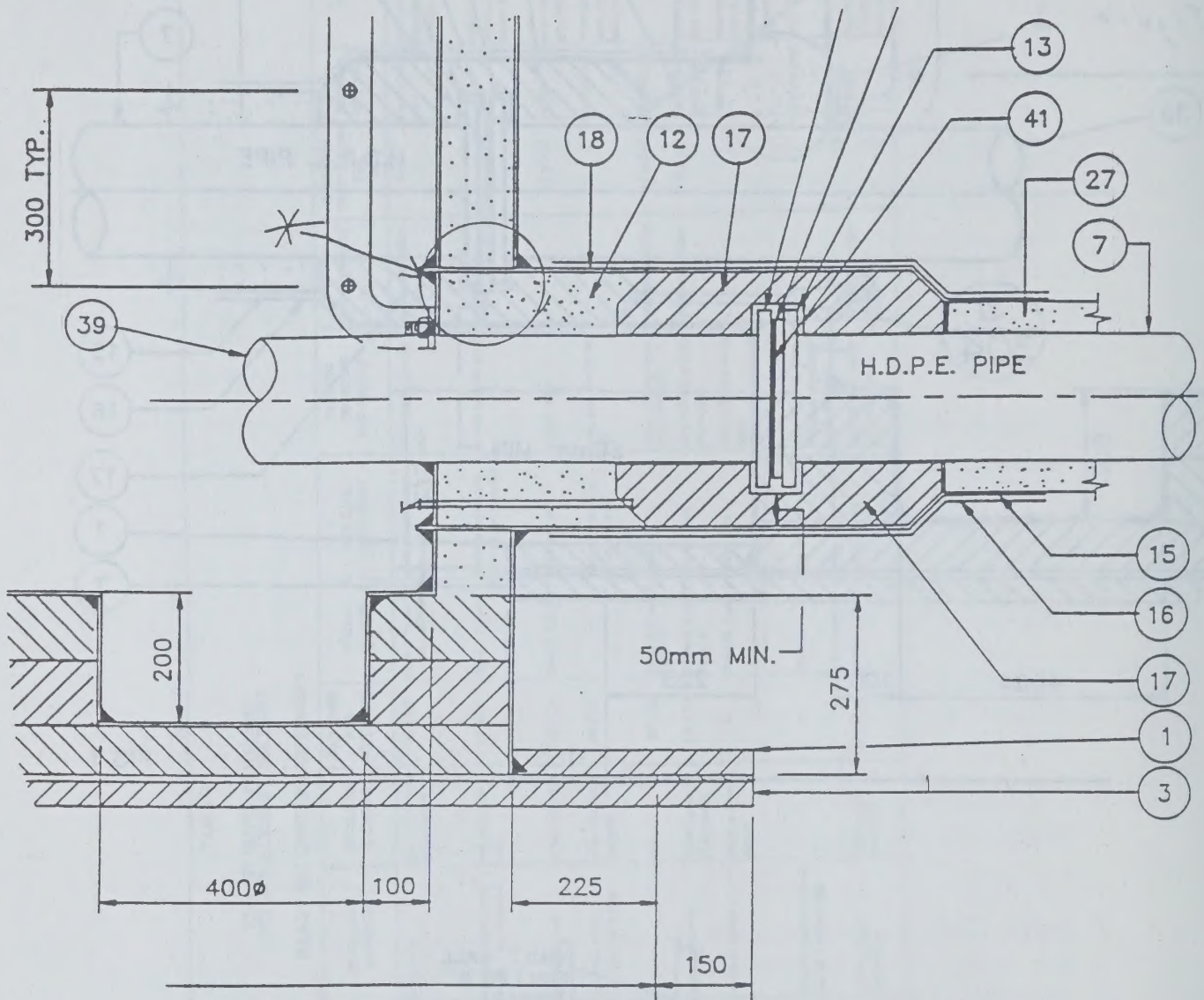
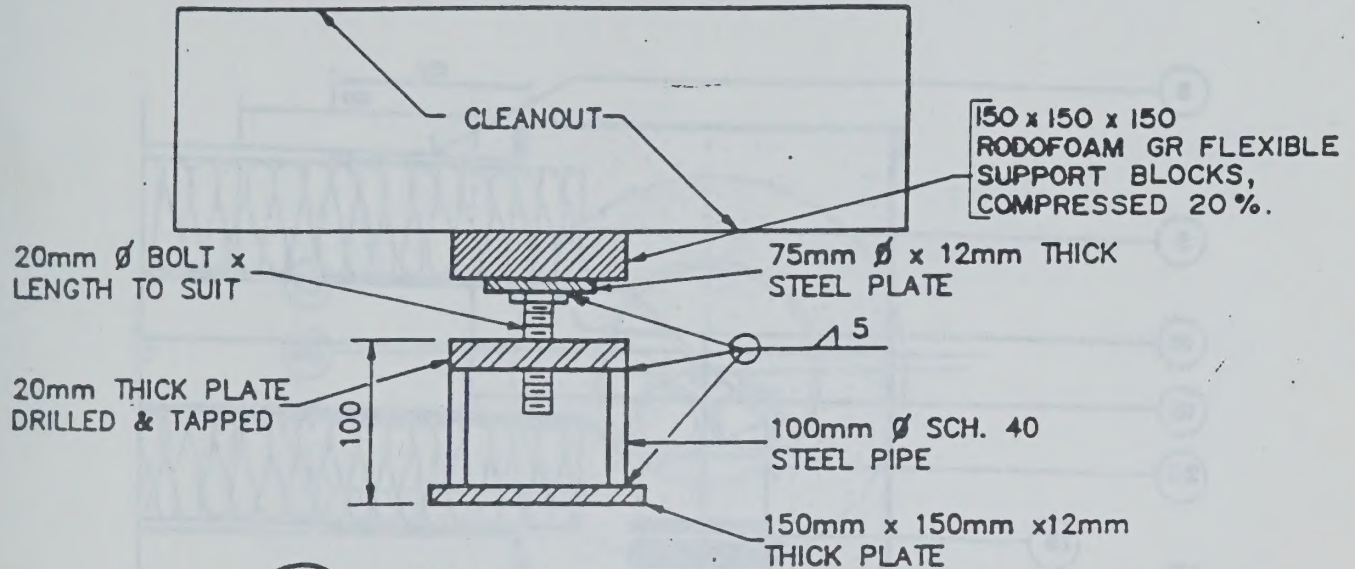


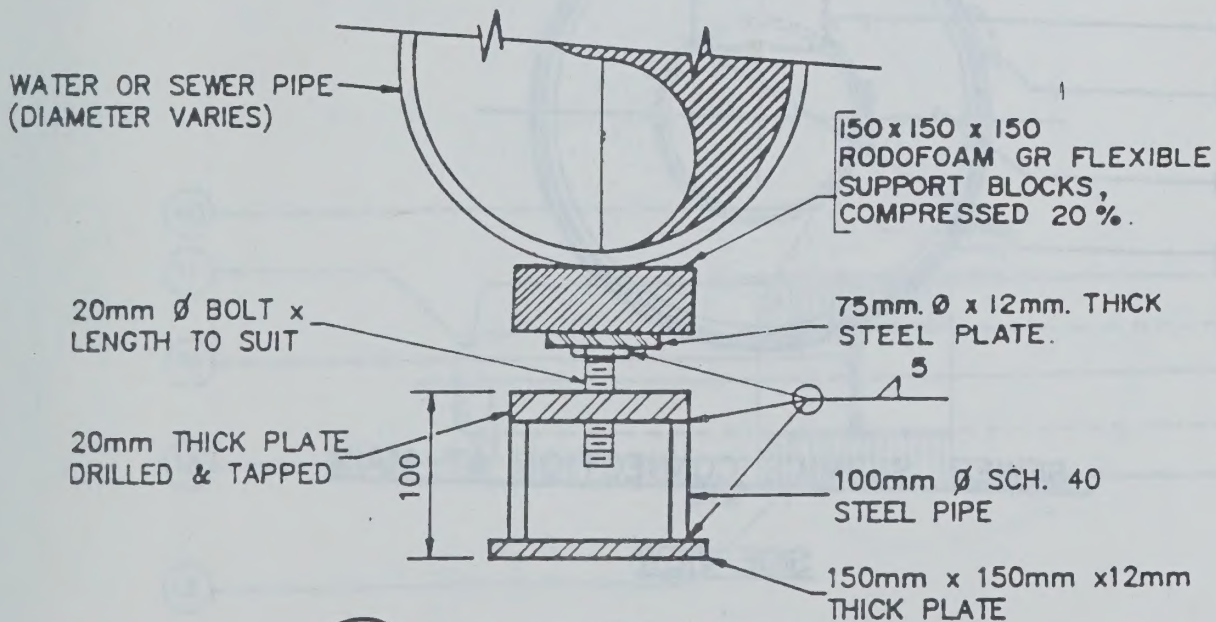
FIG 2



4 SUPPORT DETAIL
305

SCALE 1:5

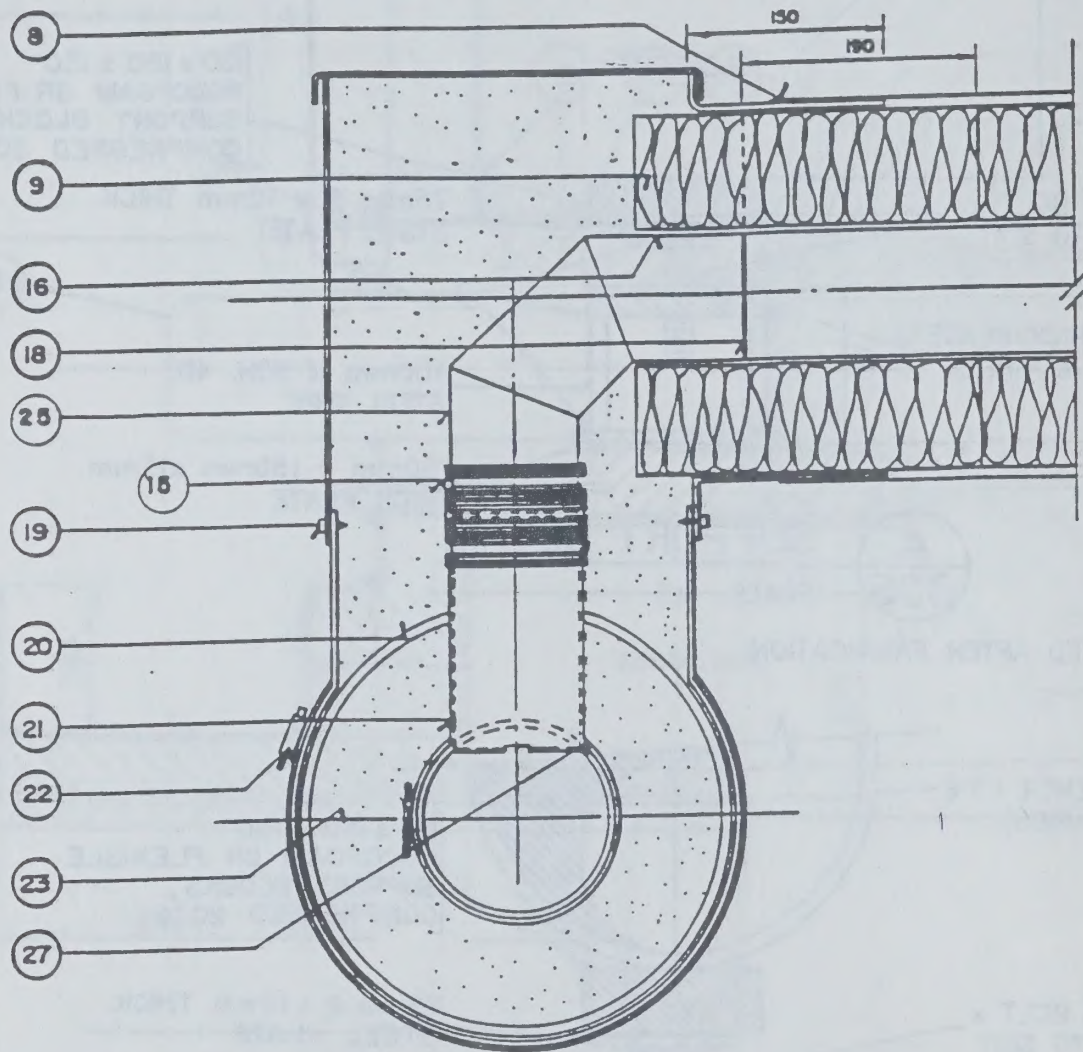
NOTE:
GALVANIZED AFTER FABRICATION



5 SUPPORT DETAIL
305

SCALE 1:5

NOTE:
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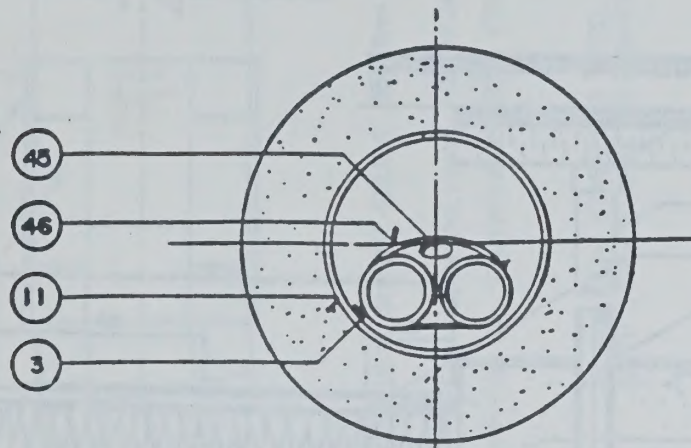


SEWER SERVICE CONNECTION AT MAIN

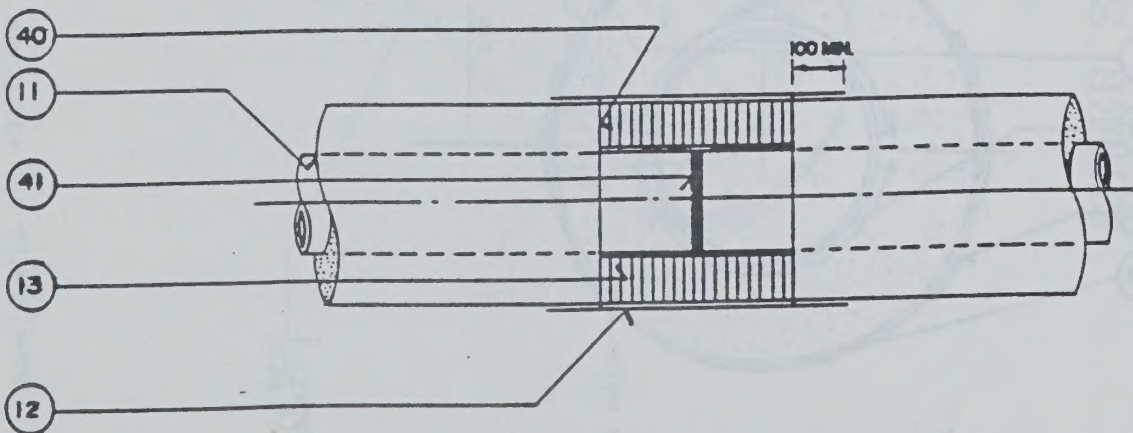
N.T.S.

SIDE VIEW

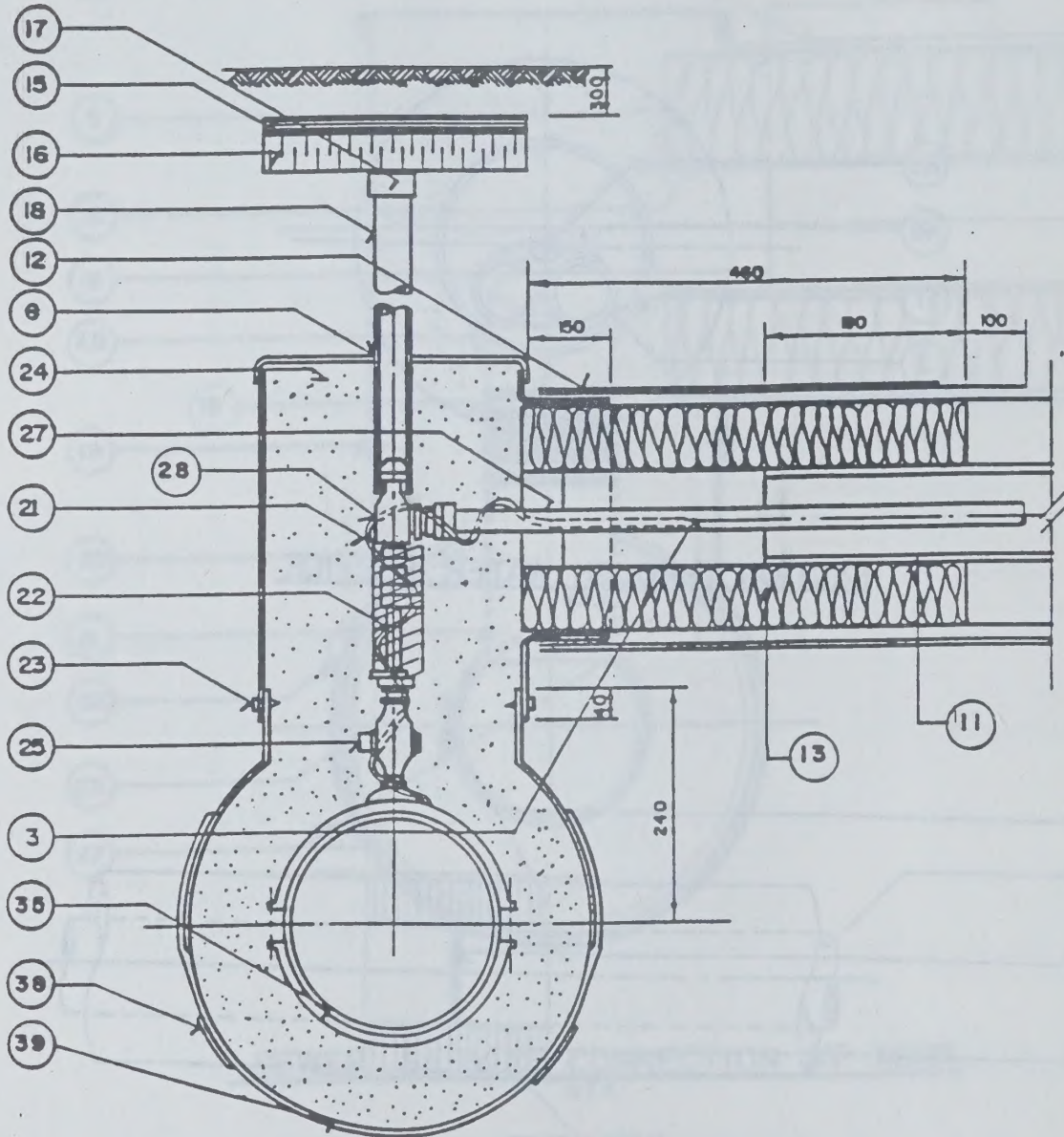
FIG 5



SECTION THROUGH WATER SERVICE
N.T.S.



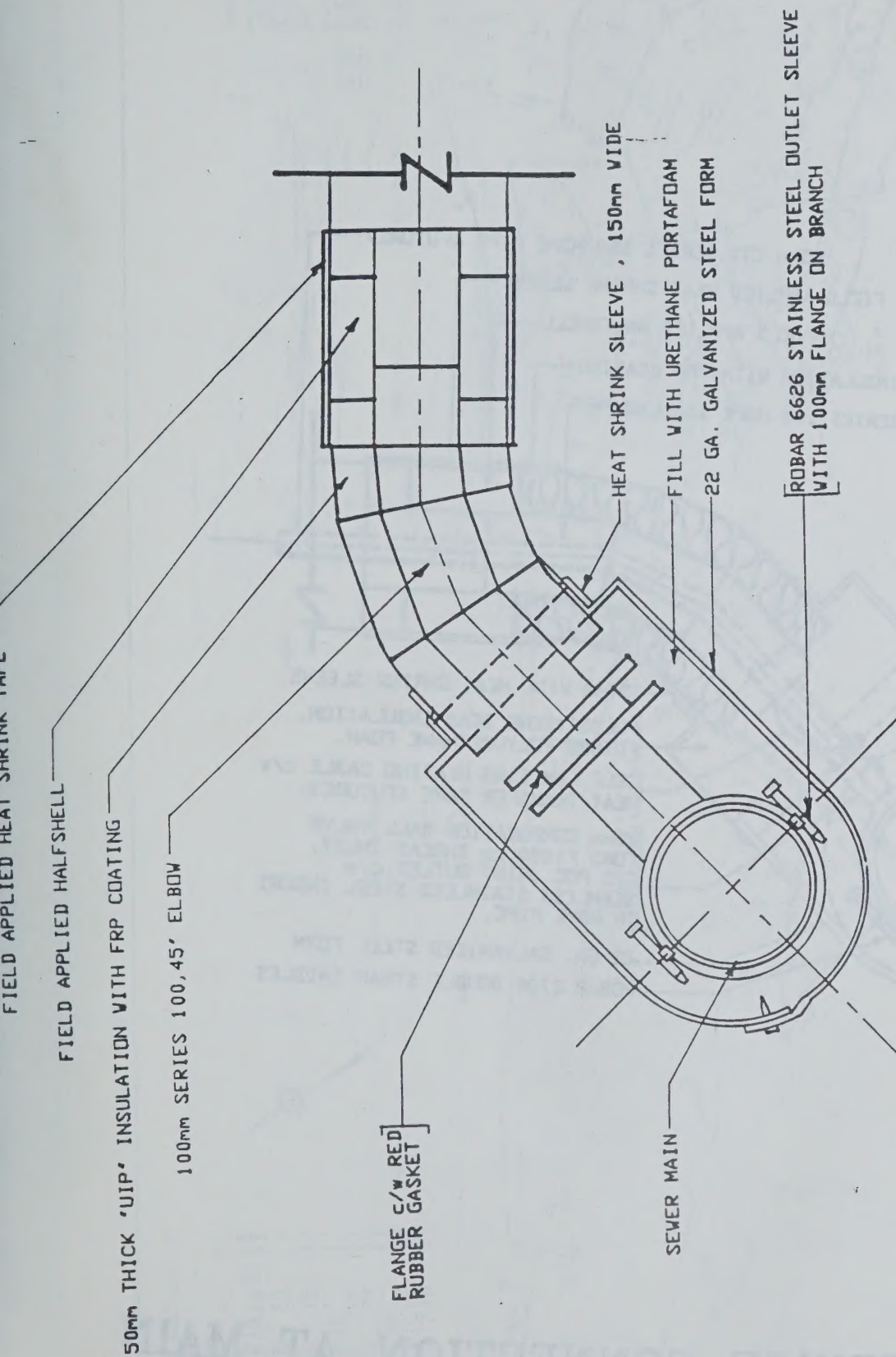
TYPICAL JOINT ON SERVICE CONNECTIONS
N.T.S.



WATER SERVICE CONNECTION AT MAIN

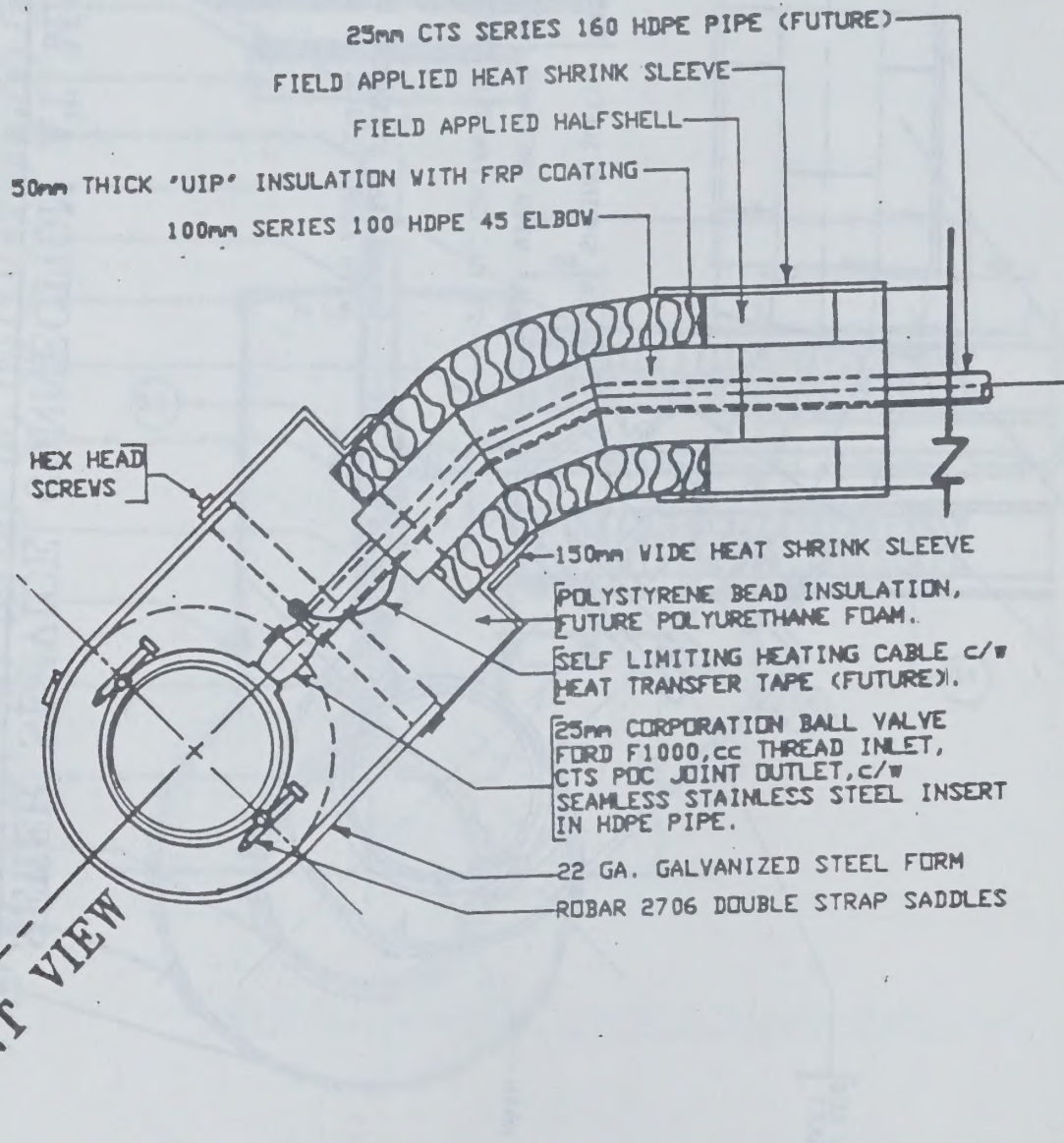
N.T.S.

SIDE VIEW



SEWER SERVICE CONNECTION AT MAIN

122

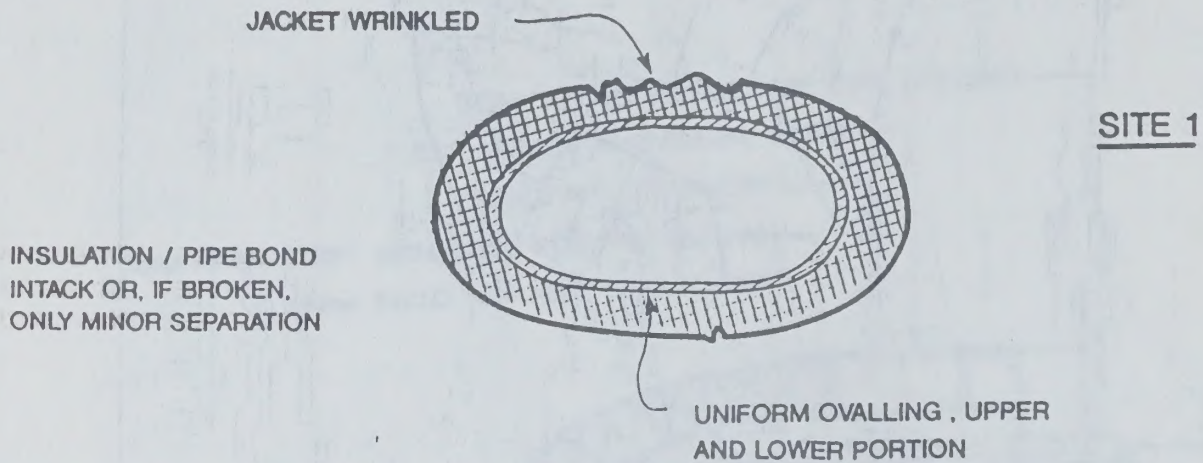


WATER SERVICE CONNECTION AT MAIN

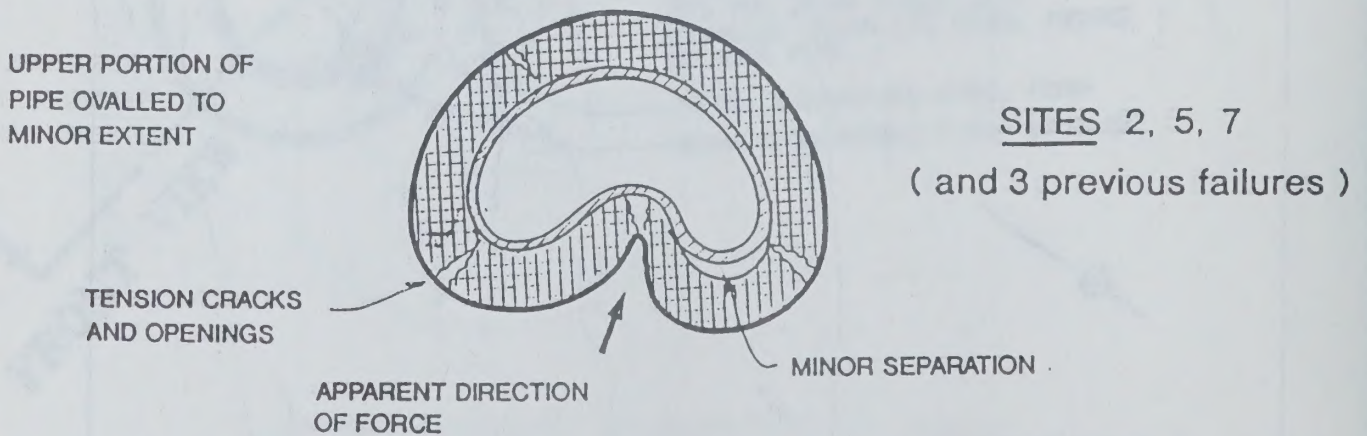
FIG 9



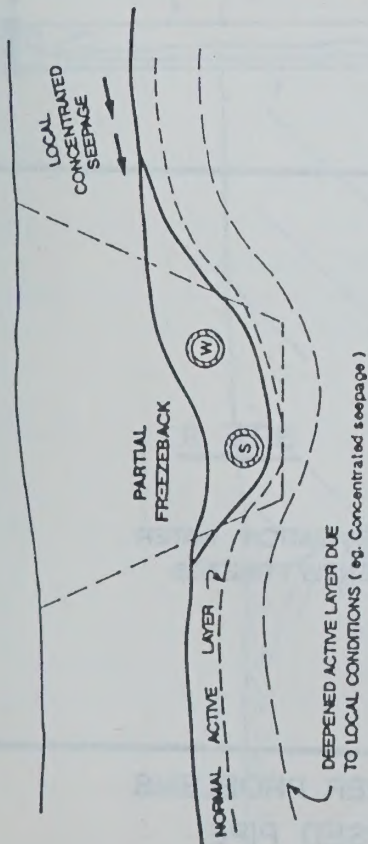
FAILURE A1



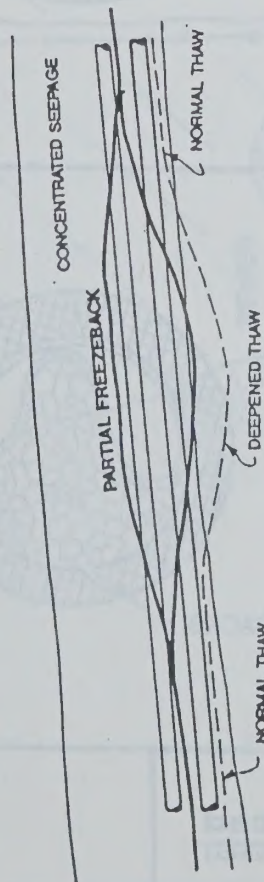
FAILURE A2



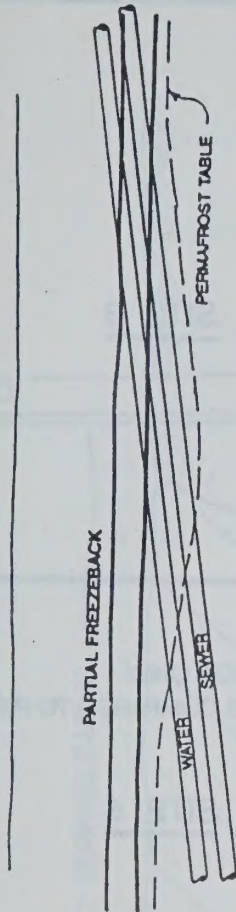
4a) SECTION ACROSS TRENCH



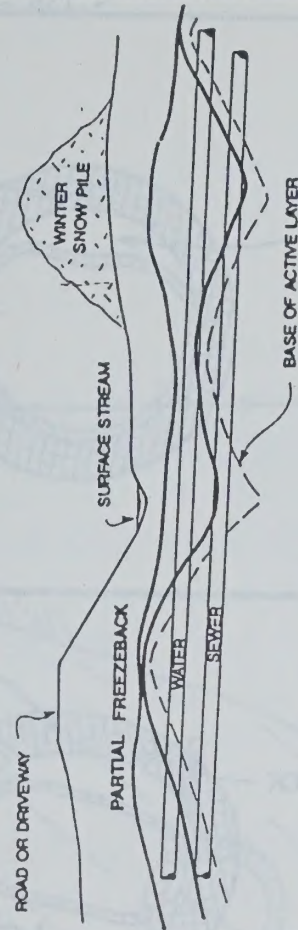
4c) SECTION ALONG TRENCH



4b) SECTION ALONG TRENCH (Level Ground)



4d) SECTION ALONG TRENCH (Variable Ground Surface / Conditions)



Hardy BBT Limited
CONCRETE ENGINEERING & INSTALLATION SERVICES

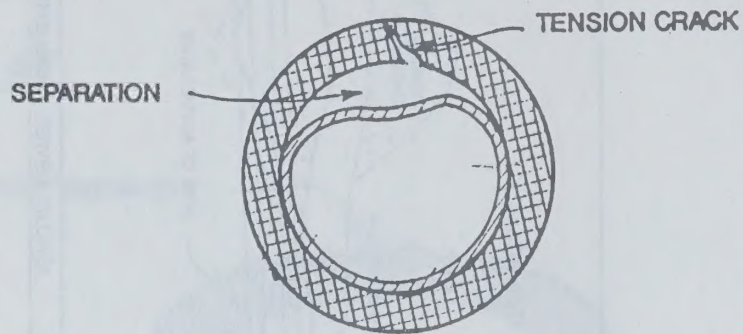
IOALUIT SEWER PROBLEMS

TRENCH SECTIONS - PARTIAL FREEZEBACK

YX00114

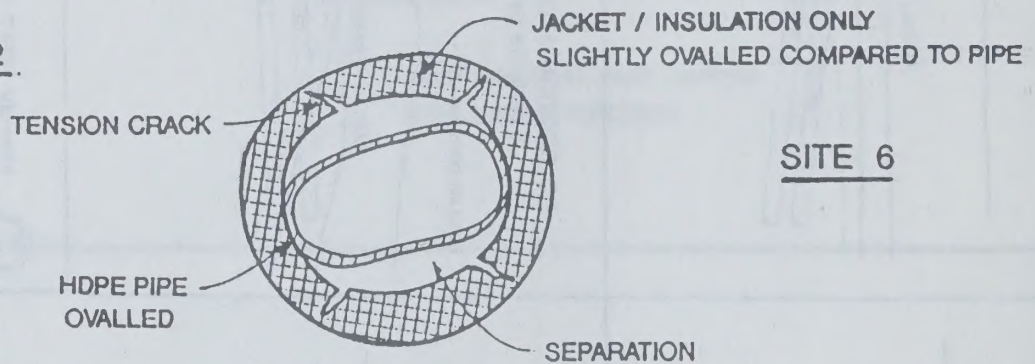
FIG 12

FAILURE B1



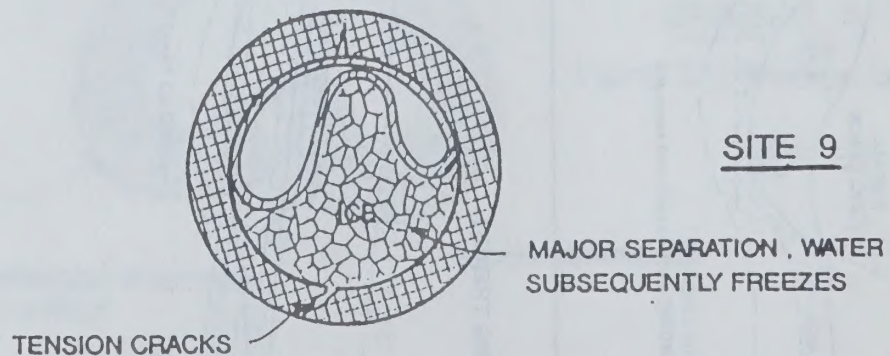
SITE 3

FAILURE B2



SITE 6

FAILURE B3



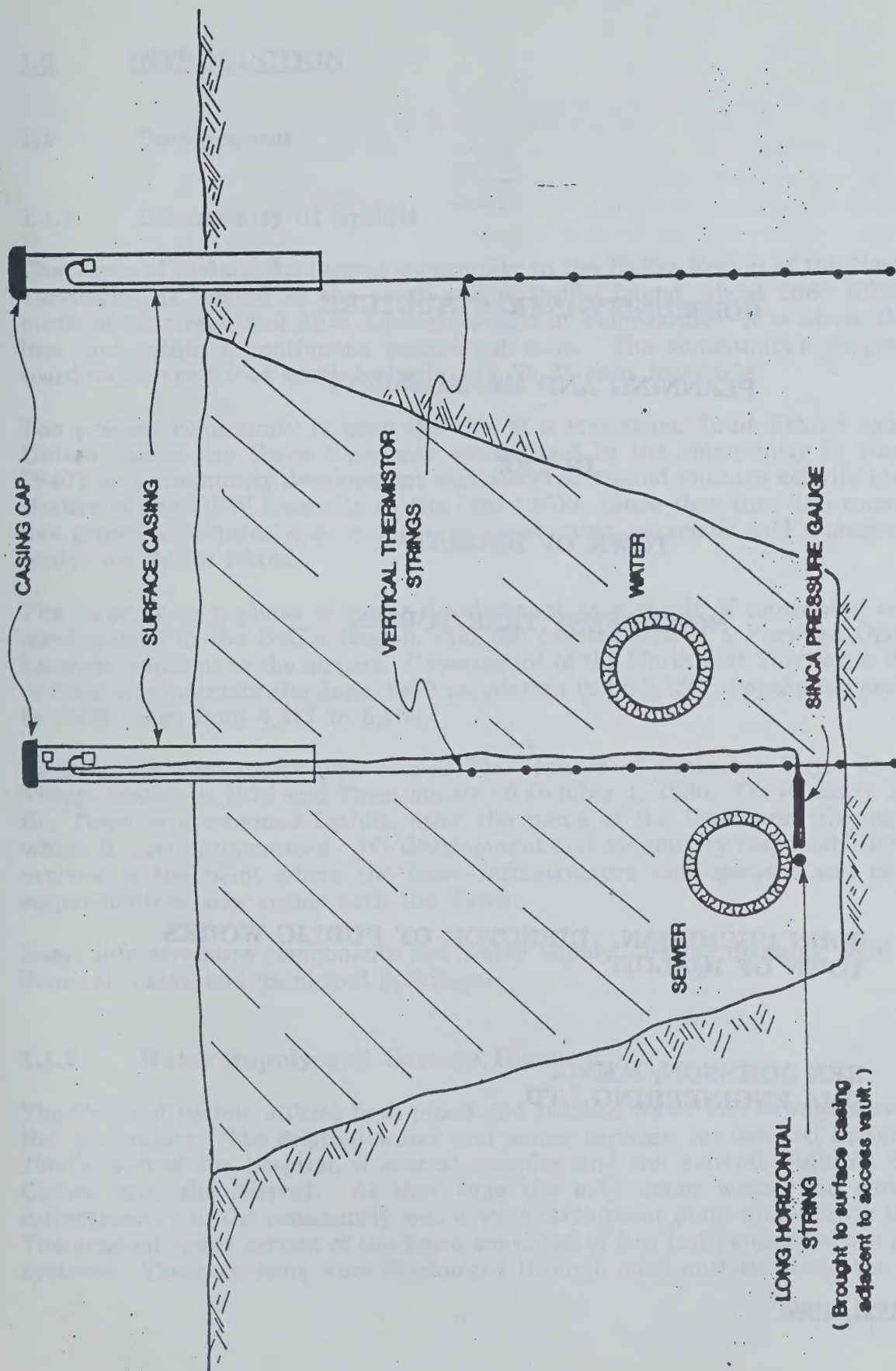
SITE 9



Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

IQALUIT SEWER PROBLEMS
COLLAPSED PIPE
PRESSURE INSIDE JACKET

FIG 13



INSTRUMENTATION LAYOUT

FIG 14



**COMMUNITY INFRASTRUCTURE
PLANNING AND MANAGEMENT
IN THE
TOWN OF IQALUIT
NORTHWEST TERRITORIES**

**BY: JOHN CUCHERAN, DIRECTOR OF PUBLIC WORKS
TOWN OF IQALUIT**

&

**KEN JOHNSON, P.ENG.
UMA ENGINEERING LTD.**

DECEMBER, 1990

1.0 INTRODUCTION

1.1 Background

1.1.1 Community of Iqaluit

The Town of Iqaluit, the largest community in the Baffin Region of the Northwest Territories, is located on the south end of Baffin Island, about 2060 Kilometers north of Montreal, and 2275 kilometers east of Yellowknife. It is above the tree line and within a continuous permafrost zone. The community's geographical coordinates are 64 44 north latitude and 68 31 west longitude.

The present community is near the site of a traditional Inuit fishing camp. A United States Air Force Base was established in the community in the early 1940's and community development was centered around military activity until the closure of the DEW Line site in the late 1960's. Since that time the community has grown significantly; as a regional government, economic and transportation centre for Baffin Island.

The Town is in a phase of major development as a result of continuing regional development in the Baffin Region, and the construction of a Forward Operating Location adjacent to the airport. Government of the Northwest Territories Bureau of Statistics estimate the June 1989 population to be 3,126. Population estimates to 2008 range from 4,377 to 5,200.

In 1971 the community was named The Hamlet of Frobisher Bay. It gained Village status in 1974 and Town status on October 1, 1980. On January 1, 1987 the Town was renamed Iqaluit, after the name of the traditional fishing camp which it now encompasses. It's development and community responsibilities have evolved to the point where the basic infrastructure management and planning responsibilities now reside with the Town.

Basic infrastructure components are water supply, sewage disposal, solid waste disposal, roads and municipal buildings.

1.1.2 Water Supply and Sewage Disposal

The Town of Iqaluit utilizes both piped and trucked water and sewage services in the community. The original water and sewer services, constructed in the early 1960's, served the hospital, a central complex and the Federal Building Service Centre near the Airport. At that time the only major water and sanitation infrastructure in the community was a water treatment plant and storage facility. The original sewer system of the Town consisted of four independent above ground systems. These systems were discharged through open outfalls along the beach.

Construction began in 1976 on a multi-phase project to expand the piped water and sewer system. Projects in 1976 and 1977 saw construction of buried water and sewer piping and pumping stations. In 1978, the construction of a sewage lagoon permitted discontinuation of sewage discharge through the open outfalls along the beach.

A macerator was also constructed in 1978 in conjunction with the lagoon for the prime function of "chopping up honey bags" for discharge into the lagoon liquid waste. The facility had never been operated successfully and was therefore abandoned.

At the present time the piped water and sewer system constitute approximately 2/3 of the system while it is estimated that the trucked water and sewage services constitute the remaining 1/3. This 1/3 includes the satellite community of Apex.

Bagged sewage (honey bags) use was discontinued in 1986 when the Town initiated a bylaw authorizing only sewage pumpout service or piped sewer service within the community.

The trucked water system consists of one tandem axle 15,000 litre water truck, three 10,000 litre single axle water trucks and two truck fill points.

The trucked sewage system consists of a tandem axle 14,000 litre sewage vacuum truck, a single axle 10,000 litre vacuum truck and two sewage dumping stations.

The piped water and sewage system consists of approximately 45 kilometers of trunk lines, distribution lines and service lines. Pipe materials consist of asbestos cement, ductile iron, C.M.P., mild steel and series 45, 60, 80, 100 and 160 H.D.P.E. Also part of this system are a raw water storage lake, water treatment plant, treated water storage, water booster pump-house, five water reheat and recirculation stations, one recirculation station, two submarine sewage lift stations, 197 access vaults/manholes and a sewage lagoon.

Primary sources for heating the domestic water are; high temperature hot water provided by the Northwest Territories Power Corporation and distributed by the GNWT Department of Public Works injected at three locations and oil fired boilers situated in two strategic locations in the system.

1.1.3 Solid Waste Disposal

Over the years a total of six sites have been used for solid waste disposal. Two sites are presently active with one being used for domestic waste and the other primarily for the stockpiling of metal wastes. The Town has two garbage trucks which pick up residential wastes twice per week and the wastes from commercial establishments five times per week. The domestic waste site has been filled to beyond capacity for a number of years and plans are under way to reactivate one

of the abandoned sites to provide for relocation of the Municipal Waste Disposal Facility.

1.1.4 Roads

There are approximately 33 kilometers of road within the Town, of which approximately 5.5 kilometers are paved.

Road maintenance activities include ditching, grading, sign maintenance, snow plowing and removal, street sanding, road topping, dust control and granular source road maintenance. Equipment used to carry out these functions are a grader, two rubber tired dozers, two front end loaders, a tracked dozer, a sand truck, a snow blower, a steam boiler, two dump trucks and a contract back-hoe when necessary for ditching.

Approximately 3,000 M3 of 3/4" minus road topping material are applied each year to maintain the gravelled road surfaces. Approximately 5,000 M3 of street sanding material is stockpiled each year for winter use.

1.1.5 Municipal Buildings

There are approximately 16 buildings which the Town owns/leases which must be adequately maintained.

These include three recreation facilities, five public works garages, eight staff accommodations and the town hall/arena/firehall.

1.2 Historical Operation

1.2.1 Water Supply and Sewage Disposal

The trucked systems were operated by private contractors up until 1983 when the municipality began performing this service with their own forces. The size of the truck fleet has only increased by one water truck since that time.

The piped system has been operated and maintained by the Federal Government who later transferred ownership and responsibility to the GNWT Department of Public Works. In 1989 the Town began the transfer process of this system over to the Town via the "Turnover Acquisition Agreement". The transfer of operational requirements was to be phased in with the GNWT Department of Public Works operating the system under an "Operating Agreement" until the Town was fully capable of assuming this function.

1.2.2 Solid Waste Disposal

In 1981 the Town assumed the responsibility of picking up and handling domestic and commercial waste. Prior to that time waste was simply deposited where it was convenient and hence the six waste sites. Both the American and Canadian Military contributed substantial amounts of both domestic and metal waste. Metal wastes consisted of vehicles, aircraft bodies, oil barrels, etc.

1.2.3 Roads

Up until 1972 the Federal Government maintained all roads in the community. When Frobisher Bay was made a Hamlet the equipment and personnel were transferred over and the responsibility for road maintenance became the municipalities. The paved roads were done in 1977 in conjunction with the paving of the runway and financed by a municipal debenture.

1.2.4 Municipal Buildings

All of the buildings presently owned by the Town were transferred over to the Town during the transfer of various Federal and Territorial Government responsibilities to the Town.

These included Public Works garages, Recreational facilities, Social Services and Public Works staff housing.

2.0 MANDATE FOR COMMUNITY OWNERSHIP AND OPERATION

As the community grew the needs changed and the move towards a level of self determination was pursued by both the community and senior levels of government. The responsibility for infrastructure management has progressed through various phases with negotiations in some cases taking some ten years or more to finalize.

Through the years various territorial and federal legislation has been enacted which defined much of the Towns' mandate.

In order for the Town to successfully assume these responsibilities and effectively perform the required functions, it became necessary to enter into a number of agreements for ownership and operation.

A Community Works Management system is being developed to effectively manage the Towns' infrastructure. This will be a maintenance management system that will eventually tie in to the newly implemented financial information system.

2.0 OWNERSHIP

2.1 Ownership Transfers

Transfer of ownership of the Towns' infrastructure and associated lands has been essentially from the federal government to the territorial government then to the Town; although this has not been the case in all instances.

2.1.1 Property

During initiation of Frobisher Bay as a Hamlet a sole vendor agreement was being negotiated with the GNWT which would turn over all lands within the municipal boundaries to the municipality. This would have included all land for municipal use as well. The Settlement Council and again the Hamlet Council wished to then control ownership of the land and not sell it, but, instead lease it. The GNWT objected to this and in effect a land freeze was in effect until 1978/79 when the Village Council and the GNWT renegotiated the conditions of a "sole vendor" agreement.

Prior to signing this agreement though, the Tungavik Federation of Nunavut (TFN) stepped in with land claims demands and forced a land lease only policy into place that is still in existence.

In 1969/70 much of the municipality was surveyed and as recent as 1990 road rights of way and utility easements were surveyed to accommodate ultimate transfer of lands occupied and necessary for municipal infrastructure purposes to the municipality. Until ownership is possible, lands which are federally owned will be transferred to the GNWT at which time the GNWT will lease all the necessary lands to the municipality.

2.1.2 Facilities and Equipment

As the municipality grew and responsibilities were transferred from the Federal government and the GNWT various facilities and pieces of equipment were also transferred. The earliest transfers were equipment and facilities for road maintenance which were transferred to the Hamlet in 1971/72.

Since that time the municipality has made acquisitions utilizing its' general revenues, it has seen facilities transferred from private organizations such as the Independent Order of the Daughters of the Empire (IODE), as well as from the GNWT. The Town has also made some acquisitions with funding provided by other governmental agencies.

2.1.3 Agreements

Agreements were entered into which provided for the transfer of management responsibility, assets and operational responsibility. Some of the agreements covered not only the infrastructure requirements of the Town, but, also other mutually agreed upon services that the municipality would provide. These include the Road Maintenance agreement with the Federal Department of Indian and Northern Affairs, the Social Services agreement with GNWT Departments of Social Services and Local Government, the Turnover/Acquisition agreement with the GNWT Department of Municipal and Community Affairs and the piped water and sewer system Operating Agreement with the GNWT Department of Public Works.

Within each of these agreements were sub-agreements which provided for phased in implementation.

3.0 INFRASTRUCTURE DEVELOPMENT

3.1 Infrastructure Planning and Financial Management

Iqaluit has fallen behind in many ways in its infrastructure planning due to the long and sometimes onerous transfer of responsibility from the GNWT. Coupled with this has been the high turnover of personnel that the Town has experienced during its growth period. In efforts to catch up with the needs, careful assessment of the immediate situation was necessary, although, in many situations time has been of the essence and much of the planning, project management and financial management have been very fast track. Over the next five years however, the Town will move toward establishing phases for infrastructure development that will see the phases staged over a number of years. This will include planning in year one, design in year two, construction in year three, etc. and post construction/warranty and monitoring over the last two years of a project.

3.1.1 Needs and Priorities

Essentially immediate needs have had to be assessed and prioritized in conjunction with the priorities of both Town Council and various governmental agencies having jurisdiction. Short term and long term needs must then be assessed and prioritized. This is normally done through briefing notes describing the need, general scope of work, financial impact, political impact and associated implementation plans such as the five and twenty year capital plans.

Town Council would set priorities and Town Administration would endeavour to coordinate these priorities with available Town resources and general revenues, as well as, available resources from other sources in the form of fees for service, grants, subsidies, debentures or cost sharing programs.

3.1.2 Planning

Once the planning stage is entered the goal would be to refine the scope of work, the costs and the required time frame in order to accomplish the identified objective.

This is normally carried out by engaging the services of a consultant to carry out any required studies and perform detailed analysis of potential viable alternatives. The recommendations would be presented to the Town who would review them with all affected parties. It is important to note that a Consultant with Cold Regions Engineering experience is vital if not essential.

Once the final planning document is complete the information would be utilized for refining the scope of work, project design budgets and initial construction budgets.

3.1.3 Design

Generally the design for the project would be awarded to the consulting firm who has performed the planning, if their performance has been satisfactory and they have demonstrated the ability to perform the necessary design, resident inspection and post construction engineering services. A completed design will again afford the opportunity to further refine budgets and timing.

During the design stages close liaison between the consultant, the Town and other affected agencies is vital. Cold Regions Engineering is still very much in its infancy and careful attention must be paid to observations made by other operational and technical individuals who have had pertinent experience in buried water and sewer systems, road works in permafrost regions, arctic building construction and arctic waste management and disposal.

The design should undergo scrutiny at the 50%, 80% and 100% stages prior to tendering. In most cases where construction is involved all projects for the following construction season must be tendered and awarded by the beginning of april at the latest. This is necessary in order to have materials and equipment brought into Iqaluit on the annual sealift. In general the sealift boats begin to arrive in late july to the beginning of august.

3.1.4 Construction

Most if not all the construction in Iqaluit must occur between the end of june to the middle of october. In many cases the construction window is diminished should material and equipment have to come in on the sealift boats. This means that there is only 2.5 to 3.5 months to perform the work.

During the tender award process the past performance of contractors, the size and relative condition of contractor equipment and other contractor resources are carefully evaluated recognizing that each of these components are vital to the successful completion of a project.

The Town strongly prefers to utilize local contractors and labour as much as possible although it does not have a formal local or northern preference policy. It does however take into consideration the noted northern and local content in awarding the contract and this item is included for information in the tender documents.

The Towns' tender documents also stipulate the date the work must be complete which the contractor must be prepared to commit adequate forces to comply with. Contract terms and conditions are such that the contractor is strongly encouraged to complete by the stipulated date. Extensions are considered only if a situation arises where there is no doubt the contractor had every effort to complete on time and the delay was a result of conditions outside the contractors power to deal with.

During construction 100% resident engineering inspection takes place with daily logs, reports and photos logs generated by the consultant and signed off by the contractor. The reports are submitted weekly to the Town with a weekly summary of activities for review by the Towns' project officer. A pre-construction meeting takes place shortly after the award of the tender to ensure that the contractor is fully aware of site and procedural requirements. Bi-weekly site meetings also take place during construction and are attended by representatives from all agencies who have an interest in or are affected by the project.

Depending upon the size, scope and funding of a project the construction may take place over a number of years.

3.1.5 Post Construction, Warranty and Monitoring

Once construction is complete on a phase the construction warranty period is two years. This allows for an opportunity to tie up all the loose ends that are often left hanging at the end of the construction window. It also allows for all the new infrastructure, including deficient items from previous years work, to go through at least a full seasonal cycle.

If during this period a problem arises relating to poor installation or equipment failure the Town maintains a holdback throughout the warranty period to ensure that corrections are made in an expeditious manner.

The Consultant is also under contract with the Town during this period to handle construction problems that may arise, as well as to monitor the effectiveness of the design and note necessary changes for future designs.

In order to achieve efficient cost effective engineering design in the north this monitoring phase is crucial. Should the monitoring phase be ignored or overlooked there would exist the potential for the replication to inadequate design and/or construction.

3.1.6 Funding

The Towns' funding for infrastructure management comes from a variety of sources. As a tax based municipality property tax and grants in lieu of taxes constitute the majority of the Towns' general revenue. Other sources come from sales of service, tariffs, subsidies, grants and debentures.

Funds for operating and maintaining the water, sewer and solid waste systems are received through the application of tariffs. The water tariff is based on the expense of annual delivery of the service divided by the billable metered consumption. The GNWT in some instances subsidises the water tariff for selected groups of consumers. The garbage tariff is based on the cost of providing service divided by the number of annual pickups. Presently there are not any subsidies available on garbage tariffs.

Capital funding is also available from the GNWT under its water and sanitation program for major new facilities and trunk mains. Replacement of distribution infrastructure will be replaced through an infrastructure replacement reserve which is a component of the water tariff.

Capital funding for solid waste disposal is only available from the GNWT for access road construction and only in limited amounts from the Federal Government under the Environmental Partner Program, Metal Waste Cleanup Program and the Green Plan. Any funds required for solid waste reclamation or relocation is borne largely by Town general revenue and/or the garbage tariff. Capital equipment purchases are funded through an equipment reserve which is a component of the garbage tariff.

Land development that requires extension to the piped water and sewer distribution network is generally funded by debenture and recaptured through 15 or 20 year land leases.

Operation and maintenance of the roads is funded through the general revenues of the Town.

Funding for municipal buildings is basically acquired through the general revenues either funded annually or debentured over a longer period of time. Debentures required for these purposes would normally require approval by the ratepayers of the Town.

4.0 SUMMARY

The Town is gaining some maturity in its management and planning of the communities infrastructure, but, it is at a critical point in its development where it must be able to very quickly react to unforeseen occurrences and especially to staffing instability. Stability is essential for the establishment of long term planning, management and maintenance of the Towns' established five year and twenty year capital plans.

Cooperation and team work between Town Council, Town Administration and the Ratepayers will ensure a vibrant and productive future for Iqaluit.

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Special Recognition

- Kathryn Garven, Town Manager, Town of Iqaluit
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- Charlene MacCormack, Director of Finance, Town of Iqaluit

